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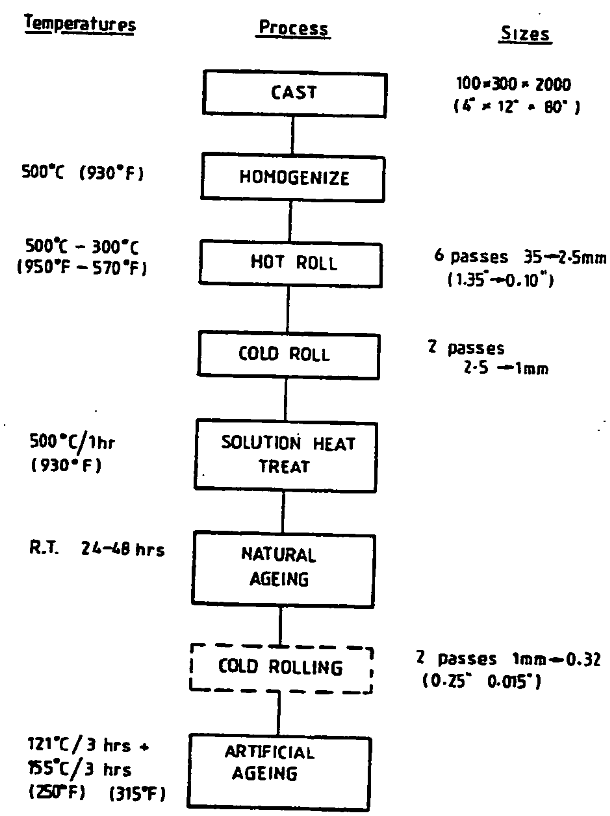
(54) Title: ALUMINIUM ALLOY SUITABLE FOR CAN MAKING

(57) Abstract

Aluminium can stock which has strength, ductility and anisotropic properties in excess of conventional aluminium can stocks. The aluminium can stock is produced from an alloy with 3.0-8.0 wt% zinc, 0.5-3.0 wt% magnesium, less than 0.7 wt% iron, 0.01-2.0 wt% silicon, 0.05-0.9 wt% copper, 0.1-1.1 wt% manganese, less than 0.3 wt% chromium and incidental impurities less than 0.15 wt%. While zirconia is not generally an impurity in these aluminium alloys it is preferable that the amount present is less than 0.01 wt%. The aluminium can stock is produced by a process comprising the steps of forming melt of the alloy metal suitable for casting, casting the melt into a form suitable for rolling, performing an intermediate rolling to an intermediate thickness, treating the alloy material with heat, performing finish rolling by a cold rolling reduction within the range of 2 to 85 % and temper heat treating the material to the desired ductility and strength properties.



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TITLE: ALUMINIUM ALLOY SUITABLE FOR CAN MAKING

This invention relates to the use of aluminium based alloys for the manufacture of liquid containers and in particular to a high zinc content aluminium base alloy suitable for liquid container construction.

Conventional two-piece aluminium beverage containers are generally fabricated from two distinct alloys such as the Aluminium Association Specification 3004 and 5182 (See Table 1). 3004 alloy is generally used for body stock by deep drawing and wall ironing forming methods but lacks the necessary rigidity and strength properties to be a useful lid stock whereas 5182 alloy which is unsuitable for body stock has the properties desirable for can lid fabrication. Increased demand for this type of container and the need for stronger cans of thinner gauge material has spurred development of new alloys and in particular alloys which can be used for both body and lid stock.

To be suitable for can body stock an alloy must possess the required combination of good formability and strength properties whilst also being economical to manufacture.

The AA3004 type alloy composition alloys are traditionally produced by casting the alloy using the direct chill casting method (DC-cast) into an ingot block of cross-section around 500 mm thick x 700 mm

wide. The ingots are then homogenised at temperatures between 500 and 620°C for 4-24 hours and hot rolled. The hot rolling procedure reduces the ingot thickness to a gauge of about 2-3 mm by a series of breakdown passes.

The material is then usually annealed at temperatures of 300 - 400°C for periods between 0.5 and 4 hrs to allow the metal to recrystallise. The annealed metal is then subjected to a cold rolling schedule to develop strength and other properties. This normally consists of 2 - 5 passes using 20 - 50% reductions to achieve a final gauge of about 0.3 - 0.33 mm.

The final gauge sheet is then fabricated into aluminium cans by use of a cupping machine and can body maker. Circular discs approximately 135 mm diameter are cut or punched from the cold worked sheet on the cupping machine and drawn into shallow cups. The cup then enters the bodymaker and is first redrawn into a cup close to that of its final diameter. The sidewalls are then reduced in thickness in one or more wall ironing operations to produce a can body around 65 mm diameter and 140 mm high with a wall thickness of between 0.10 - 0.18 mm.

The material from which the body is drawn has anisotropic properties (i.e. the properties differ with direction) and so the top of the drawn body has a scalloped top, with approximately 4 peaks oriented 90° apart the peaks of which are called ears. The degree of

"earing" is determined simplistically by the following equation:

$$2\times\frac{(h_e-h_t)}{(h_e+h_t)}\times 100 - \%\ \mathit{Earing}$$

where h_e is the distance between the bottom of the cup and peak of the ears and h_t is the distance between the bottom of the cup and valley of the ear.

For the body to be acceptable for further fabrication into a beverage container the formed body must have earing levels of no more than 3-5% and preferably less than 3%. The tops of the can bodies are trimmed off (fixed for a given process), during a slitting operation and the "eared" area is scrapped.

Another major consideration of the quality of the finished body is its ability to form in the body maker without tearing and to have a smooth surface finish, free of drawing streaks and lines. Deep grooves caused by "galling" may appear on the finished can walls if the material is not of the correct microstructure.

Downgauging of conventional strain-hardened alloys to reduce the cost of body manufacture requires the use of increased alloying element concentrations (e.g. copper, manganese and magnesium) to increase strength.

However, as these concentrations are increased, the formability of the resultant alloy decreases; in fact,

the potential strength of the 3xxx series based alloys is ultimately limited by the amount of rolling strain which can be sustained during processing before surface finish and material properties deteriorate. Other aluminium alloy systems currently used for other applications are potentially capable of achieving much higher strength levels than 3xxx series alloy.

Although, ultimately, a container can be formed from a fabricated downgauged high strength 3004 type alloy of non-galling, low earing characteristics, unless the strength is great enough to offset the strength lost from reduced wall thickness the buckle resistance of the can will be reduced.

Buckle strength of resistance is determined by applying pressure within a drawn and wall ironed can and then gradually increasing the pressure until the bottom end of the can deforms and bulges out, i.e. it buckles or the inverted dome reverses. The pressure at which the bottom buckles is then designated as the buckle strength or dome reversal pressure. To be acceptable as a can body a can formed from the alloy sheet must exhibit a buckle strength of at least 85 p.s.i. Cans drawn from high strength 3004 alloy produced using conventional direct chill (D.C.) cast methods exhibit a buckle strength of about 90 p.s.i.

Whilst the production of 3004 body stock by the ingot casting method is widely used, economic and energy

considerations would favour the manufacture of aluminium sheet by a continuous cast route. The prior art has addressed the continuous strip cast method where aluminium is cast into a thin alloy web about one inch thick. The homogenisation process may be eliminated and the hot rolling reductions to intermediate gauge are minimised using this technique and the process of hot rolling can be eliminated entirely if the desired microstructure is achieved during continuous casting of very thin strip. The material is then annealed and processed in a manner similar to ingot cast materials. At this stage, can stock produced by this method has proven unsatisfactory for further processing and can body manufacture.

Thus, it is an object of the present invention to provide an aluminium alloy suitable for can stock which has non-galling, low earing and high strength characteristics with good formability at least comparable with existing AA3004 type alloys which will allow can bodies to be made from thinner sheet feed stock. It is also an object of the present invention to provide can stock which is also suitable for the manufacture of can lids thus, allowing manufacturing of a complete two-piece beverage can from one alloy composition. The alloy will be amenable to fabrication into can stock via both tbe direct chill cast and the continuous strip cast methods. Accordingly, the invention relates to a can stock and process for

producing a can stock from an aluminium alloy comprising 3.0 - 8.0 wt% zinc, 0.5 -3.0 wt% magnesium, less than 0.7 wt% iron, 0:01 - 2:0 wt% silicon 0:05 -0.9 wt% copper, 0.1 - 1.1 wt% manganese and 0.00.3 wt% chromium. The incidental impurity level in the alloy is less than a total of 0.15 wt%.

In accordance with another aspect of the invention, the alloy is processed into feed for a can line by a process comprising,

forming a melt of the alloy metal suitable for casting,

casting the melt into a form suitable for rolling,

performing an intermediate rolling to an intermediate thickness,

treating the alloy with heat,

performing finish rolling by cold rolling within the range of 2 to 85%,

temper heat treating the material to the desired ductility and strength.

The alloy preferably comprises constituents in following weight percent ranges, zinc 4.0 - 6.5, magnesium 1.0 - 2.5, manganese 0.3 - 0.8, silicon 0.15 - 0.3, iron up to 0.45, copper 0.10 - 0.50, chromium up to 0.20 total incidental impurities less than 0.1.

While an alloy containing zirconium up to a maximum level of 0.25 wt% may be suitable for can stock, to produce a can body with low earing, it is preferable that the zirconium level is less than 0.08 wt% and most preferable that it is not added to the melt and its level is below tbh standard level of impurity for that element of 0.01 wt%.

It has been found that an alloy which falls within the above composition range achieves high tensile and yield strength properties as well as good formability and "non-galling" wall ironing quality. Thus the alloy is preferably used to produce both the body and the lid of the beverage container.

The alloy is capable of producing a can body which has a dome reversal strength in excess of 90 p.s.i. and a wall ironed thickness of less than 0.16 mm. A 3004 alloy is generally only capable of achieving such a dome reversal strength with a wall thickness equal to or greater than 0.16 mm.

The above alloy may suitably be cast by the direct chill casting method, continuous roll casting or continuous strip casting. However, if the alloy is to be produced using roll or strip casting the compositional range of the alloy can be broadened.

The amount of Zn, Mg, Mn, Fe and Si may be increased which results in higher volume fraction of

alpha phase particles after casting and a greater amount of precipitation during final processing.

The alloy sheet may be produced by a combination of rolling reduction and heat treatmant in the final stages of manufacture. Consequently, fabrication steps vary with end use requirements. However, during the performance of the heat treatment processes, it has been found that the alloy thus formed was especially adaptable to solution heat treatment of very short duration, while more lengthy heat treatments can be used to simultaneously anneal the sheet using recrystallisation anneal or recovery anneal techniques.

For container construction or for other requirements where strength and formability are important the ingot or strip cast material may be heat treated to homogenise the cast material and preferably hot rolled and then cold rolled. The material is then solution heat treated and given a cold rolling reduction. Lastly to improve strength and ductility, the alloy is aged to a temper dependent on the end use requirements.

Preferably the cast material, if ingot cast, is subjected to an additional heat treatment step to homogenise the alloy and preferably followed by a hot rolling step.

The intermediate rolling preferably is a cold

rolling stage and may employ a full anneal or recovery intermediate anneal during the cold rolling practice.

The step of treating the alloy with heat is preferably a solution heat treatment which may be followed by a natural ageing stage.

The finish rolling step is essential to the invention to provide the necessary strength properties to the final product but still must maintain sufficient ductility and formability properties to be a suitable can stock. The finish rolling is thus a cold rolling reduction in the range 2-85% and preferably within the range of 10-80% and most preferably within the range of 30-80%. The final temper heat treatment is preferably artificial ageing.

In accordance with a further aspect of the invention there is provided a can line feed produced from the alloy of the invention which preferably has yield and tensile strength of in excess of 400 MPa and a total elongation of 4% or more.

The alloy of the invention may also be used to produce can endstock which in a tempered state must have a miniumum yield stress of 310 MPa, a minimum ultimate tensile stress of [illegible]5 MPa and MIN 6% elongation.

The strengths and elongations specified above for can end stock relate to the post bake strength of the material.

Generally endstock is manufactured in coil form and is sent to tbe end makers who then coat tbe material and bake the coated sheet at modest temperatures of between 155°C and 210°C for 10 - 30 minutes. Usually a specified test for the metal is 205°C bake for 20 minutes. The can end maker then produces the can ends by conventional metal farming processes which are well known to those skilled in the art.

As can endstock made in accordance with the invention has strength and ductility properties in the "post baked" state in excess of the above miniumum values, suitable can ends can be produced from the alloy in accordance with the invention.

A further aspect of the invention is a two piece beverage container produced from the alloy of the invention. The container preferably has a wall thickness of less than 0.12 mm and a dome reverasal strength of greater than 90 p.s.i.

The foregoing and other features objects and advantages of the present invention will become more apparent from tbe following description of the preferred embodiments and accompanying drawings.

Table 1 contains details of the invention alloy range and preferred range.

Figure 1 is a flow diagram showing the overall processing details for the alloys;

Figure 2 is a Differential Scanning Calorimetry Thermal Analysis curve for the invention alloy; Figure

Figure 3(a) is a flow diagram representing the final stage fabrication of the alloy;

Figure 3(b) illustrates the effect of the final cold rolling reduction, and

Figure 3(c) represents the effects of cold working and artificial ageing on the alloy of Example 1;

Figure 4 shows micrographs of alloy 2 of Example 2 at various stages of processing in which

4(a) is the microstructure after the material is hot rolled,

4(b) is the microstructure after the material has been annealed

4(c) is the microstructure after the final cold rolling reduction

Figure 5 shows the effect of natural ageing on Alloys 1, 2 and 3 (Example 2).

Figures 6 - 8 are graphs representing the response of the alloys of Example 2 to time at a given temperature in the final ageing treatment.

Figure 9 represents the effects of natural ageing and coldwork on the alloy;

Figure 10 represents the effect of using a double heat treatment in the artificial ageing step and the effect of coldwork;

Figure 11 represents tensile results for the alloys of the invention;

Figure 12 represents strength and ductility characteristics for the alloys of the invention compared to those of conventional 3004 body stock; and

Figure 13 represents an overview of the benefits of the alloys of the invention.

An alloy in accordance with the invention comprises the following basic alloying elements (wt%): copper (0.05 - 0.9), manganese (0.1 - 1.1), magnesium (0.5 - 3.0), and a relatively high concentration of zinc (3.0 - 8.0). Furthermore, the following additives are included in the melt: chromium (0.0 -0.30), silicon (0.1 - 2.0) and iron (0.0 - 0.5).

It has been found that, after solution heat treatment the majority of the magnesium and zinc are suspended in solid solution and precipitate during the tempering heat treatment adding the required strength to the alloy.

It is essential to the invention that the silicon, manganese and iron additives be within the ranges specified above as these elements are required to form

the desired dispersed second phase distribution (alpha phase) in the alloy which is critical for the production of a non-galling wall ironed can.

Zirconium and chromium are typically found in the melt at impurity levels of less than 0.01 wt%, but if already present or added to the melt for additional strength properties, it is preferable that they are present at levels less than 0.08 wt% and less than 0.05 wt% respectively.

The effect of the very low levels of grain refining elements chromium and preferably zirconium, is that full recrystallisation of the product after, for example, hot rolling or low temperature annealing (345°C for 0.5 - 2 hours) can take place.

If the zirconium and chromium levels in the alloy exceed the specified levels in the present invention, then the wrought structure created by hot and cold rolling will be retained during solution heat treatment or anneal and the properties of the final gauge sheet will be more anisotropic. This is particularly disadvantageous if the sheet material is to go through deep drawing operations as the anisotropic properties result in material of high earing which is undesirable for the can body making process. High strengths can be obtained by increasing the concentration of these elements but formability and earing suffer as a result.

The yield strength and tensile strength of the 10 alloy in accordance with the invention is far greater than that of a 3xxx series can body material. The 3004 alloy has yield and tensile strengths of around 285 and 330 MPa respectively with 4% elongation whereas the alloy of the invention exhibits yield and tensile strengths around 420 and 480 MPa respectively with a total elongation measured on a 50 mm gauge length of 4% or more. When such a sheet is drawn and wall ironed into a body for a two-piece beverage container it possesses can buckle strengths in excess of 100 p.s.i. with a wall thickness of 0.12mm. The very high strength and improved ductility of this alloy over any type of 3004 or modified 3xxx series alloy allows the gauge of sheet used for the initial forming operation (can line feed) to be reduced by at least 10% while still retaining buckle strength and formability in the finished body.

The high strength of this alloy also allows it to be made into lid stock for cans. Alloy AA5182 which is currently used for beverage can lids has a tensile strength of 395 MPa and an elongation of 4%. The 3004 alloy is generally not used to produce lid stock as it does not have sufficient strength for the desired lid thickness. The invention alloy can match the properties of AA5182, and thus a two-piece can may be made from one alloy composition instead of the conventional two.

When the alloy is cast by the DC-casting method to produce can bodies it is first homogenised. The cast is preferably homogenised as a block between 480° and 500°C for a period of 5 to 10 hours. The material is then hot rolled preferably from a temperature of up to 500°C down to a thickness suitable for coiling (preferably less than 5 mm). It is preferable that the hot rolling coil finishing temperature is above about 300°C as the alloy will automatically anneal during the coiling operation.

The material is then cold rolled and preferably employs a full anneal or recovery intermediate anneal during the cold rolling practice. After this rolling stage the strip preferably has a thickness of between 0.8 and 0.4 mm. These thicknesses are required as a rolling reduction must be effected during the final processing to can sheet gauge to provide the necessary sheet flatness and final gauge strength. Next a solution heat treatment at temperatures preferably between 480°C and 595°C for duration times between 5 seconds and 1 hr is followed by a water quench to ambient temperature.

A solution heat treatment for duration times toward the upper end of the range will also anneal the material if it has been cold rolled prior to the solution heat treatment. Nevertheless, the composition of the alloy allows the material to be heat treated for much shorter times than would normally be performed in processing

3004 alloys.

The alloy strip may then be allowed to naturally age at room temperature preferably for a period of zero to 48 hours prior to cold rolling of the strip.

To provide the necessary strength properties in the metal, it is necessary that the finish rolling step, has a cold rolling reduction within the range 2 to 85 percent, the reduction preferably being 10 and 80% and most preferably 30 and 70%. It has been found that even with a cold rolling reduction towards the upper limits of this range, the necessary ductility and formability properties for a viable can stock are present.

Finally the sheet material is aged to a temper between the underaged and over-aged states. The ageing will depend on the equipment used and the can manufacturer's strength and ductility specifications and is preferably within the range 120 to 26°C for a time of between 1 minute and 4 hours.

Solution heat treatment of the material prior to the final processing recrystallises the material and reduces the anisotropic properties created by the cold rolling schedule. This means that when given a final rolling reduction and fully aged to the desired temper, a deep drawing material is created which has very low anisotropic properties and very low earing levels. A cup formed from final gauge 3004 or modified alloy

typically has an earing level of 3%, whereas a cup formed from an alloy of the present invention has earing levels of less than 2%.

An alternative to the direct chill cast method is that the alloy can be strip cast in a conventional strip caster and solidified into a web approximately an inch or less in thickness. The molten alloy feedstock for this, may be richer in composition than that used in the DC cast alloy but would be of the preferred invention alloy range (see Table 1). It is then preferred that the strip is given a hot or cold rolling reduction in sheet thickness of at least 25% and more preferable 50 to 85%.

The alloy composition of the present invention and processing technique allows liquid container bodies to be made from thinner gauge sheet stock and achieve cost reductions. Furthermore, one alloy can be used for body end stock and easy-open tab stock by varying the processing steps of the alloy. The use of a single alloy type for all of the component parts of liquid container results in production costs benefits and improvements in scrap recycling efficiency.

The alloy of the invention is now demonstrated in the following Examples.

An alloy with the following composition (wt%) was direct chill cast to an ingot size of 50 cm x 120 cm

	zn	Mg	FE	Si	Cu	Nn	CrAl
4.83	1.53	0.35	0.16	0.019	0.47	0.01	balance

The ingot was subjected to the following schedule to produce a coil of the sheet.

- homogenise 5 hrs 4800° - 595°C
- hot roll to 3.175 mm

  coil exit gauge temperature 295 - 315°C
- standard edge trim applied
- anneal 370°C - 373 for 3 hours
- cold roll 60% reduction to 1.22
- solution heat treatment at 1.22

  flash solutionise at 585°C for 10 seconds
- cold rolling reductions 40% to 0.73 mm

  37% to 0.454
- 35% to 0.303 mm
- level and solvent wash
- artificial ageing to T87 temper
- age at 160°C for 1 hr.

In the schedule, the coil, once heat treated, was rolled in back-to-back passes to final gauge with a

maximum delay of 48 hours before commencing to roll.

Levelling was performed within 5 days of cold rolling to avoid eccessive natural ageing as the material age hardens after cold rolling.

An average of 50 samples tested gave

yield strength = 393 MPa

ultimate tensile strength = 406 MPa elongation 4%
ductility = 4.34 mm

Can bodies produced from the samples showed a dome reversal of 105 p.s.i. from 0.30 mm dome wall thickness. Figure 3(b) illustrates the effect of the final cold rolling reduction on the strength and ductility of the alloy and Figure 3(c) demonstrates the effect of artificial ageing time on strength and ductility of the above alloy after solution heat treatment (S.H.T.) and 70% cold rolling reduction. The ageing temperature is 250°F (121°C).

EXAMPLE 2

Three alloys in accordance with the invention of compositions shown in Table 1 were direct chill cast into ingots 100 x 300 mm in cross-section of 1.2 m length. The ingots were then scalped into blocks 190 mm wide and 100 mm thick and lengths of 200 mm. Each of the ingots were then heomogenised at temperature between 500°C and 585°C. A higher bomogenisation temperature was

used for the alloys of highest solute content to allow for more complete homogenisation. The thermal analysis curve of the precipitation reaction in the alloy during Heomogenisation is shown in Figure 2. The following letters represent the positions in Figure 2, where changes in the various phases occur. As is the dissolution of GP zones; B is the precipitation of $\eta' + \eta$ ($MgZn_2$) phase, C, the dissolution of $\eta' + \eta$ phase; D, the precipitation of T phase; E, the dissolution of T phase; and F the localized GB liquidation. Homogenisation and hot rolling schedules for each of the sample alloys are shown in Table 2.

To hot roll the alloys the scalped blocks were cooled to a rolling temperature of between 500 and 485°C in the furnace. The blocks were then removed from the furnace and individually rolled from a gauge of 100 mm to a finished gauge of approximately 2 - 3 mm. The microstructure of the hot rolled material is shown in Figure 4a.

The finishing temperature of hot rolling was often above 200°C which was sufficient to allow some recovery of the rolled structure prior to cold rolling to the solution heat treatment gauge. However, in the case of some of the alloy 3 samples, the material was given a recrystallisation anneal at a temperature of 345°C for 3 hours. This allowed the material to fully recover and recrystallise. The fully recrystallised grain size of

the alloy had an average diameter of 19m (ASTM 8.5) (Figure 4b).

In this softened condition the alloys were cold rolled to a number of different gauges as shown in Table 4. This was to allow for a number of different final cold rolling reductions to be made to the given final gauge material for body stock forming. A schematic of the final material processing is included in Figure 3a.

Figure 4(c) shows the microstructure of alloy 2 in Example 2 after the final cold rolling reduction and as can be seen from the micrograph the material has an alpha phase (α - Al(Fe,Mn)Si) totally dispersed within the matrix. This microstructure results in a wall ironed can body with excellent non-galling properties.

Solution heat treatment of the plate was conducted at a temperature of 500°C to put elements into solution in preparation for the final ageing procedures. A study of the natural ageing behaviour of the three alloys after solution heat treatment of 2 hours at 500oC is shown in Figure 5. The material was cold water quenched and then given a number of heat treatments. Ageing studies and hardness measurements were used to charactise the response of the alloys to various treatments. Tensie studies were then made of sheet in certain conditions to establish the yield strengths and elongations of the specific alloy treatments.

Final ageing treatment studies are show in Figures 6 - 8.

Figures 6(a), 6(b) and 6(c) show the response of the alloys to ageing at 155°C after a first ageing stage at 121°C for 1, 2 and 3 hours respectively.

Figures 7(a), 7(b) and 7(c) represents the ageing response of the alloys at 111°C with a preceding natural ageing stage of 0, 24 and 48 hours respectively.

Figures 8(a), 8(b) and 8(c) represent the ageing response of the alloys at 131°C with a preceding natural ageing stage of 0, 24 and 48 hours respectively.

TABLE 1 - COMPOSITION

3004 Range	Typically	5182 Range	Invention Alloy Range (ingot)	Invention Alloy Preferred
Mg 0.8 - 1.3	1.25	4.0 - 5.0	0.5 - 3.0	1.0 - 2.5
Mn 1.0 - 1.5	1.0	0.2 - 0.5	0.1 - 1.1	0.3 - 0.8
Cu 0.25 max	0.22	0.15 max	0.05 - 0.9	0.10 - 0.50
Si 0.30 max	0.23	0.20 max	0.01 - 2.0	0.15 - 0.3
Fe 0.70 max	0.37	0.35 max	0.7 max	0.45 max
Zn 0.25 max	0.013	0.25 max	3.0 - 8.0	4.0 - 6.5
Cr -	0.014	0.10 max	0.3 max	0.05 max
Ti -		0.05	-	-
Others 0.05 max (total)		0.15 max	0.15 max	0.10 max
Ni -			-	-
Zr -			-	0.01 max
Sr -				

TABLE 2

HIGH STRENGTH CAN STOCK ALLOY COMPOSITION

CHEMICAL COMPOSITION (wt%)

	A1	Zn	Mg	Mn	Si	Fe	Cu	Cr
Alloy 1	Bal	3.8	1.1	0.46	0.2	0.3	0.12	<.007
Alloy 2	Bal	4.6	1.3	0.42	0.2	0.4	0.10	<.008
Alloy 3	Bal	6.0	1.8	0.56	0.2	0.35	0.10	<.009

TABLE 3

	Homogenisation Temperature (°C)	Hot Rolling Temperature (°C)	Starting Thickness (mm)	Final Thickness (mm)
Alloy 1	500	500	100	2.5
Alloy 2	565	490	100	2.7
Alloy 3	585	480	100	2.8

TABLE 4
LABORATORY STUDY - EXAMPLE 2

I.D.	Gauge (mm)	Sht/Ann (C/hr)	N.A. (hrs)	C.W. (%)	AA(1) (hrs)	AA(2) (hrs)	YS (MPa)	UTS (MPa)	EL (%)	Earing (%)	Dome Rev (psi)
Al	0.320	500/1	48	10	121/3	155/3	-	-	-	0.0	62
A1	0.320	500/1	48	10	121/3	155/3	-	-	-	0.2	81
A1	0.320	500/1	48	10	121/3	155/3	-	-	-	0.1	-
A1	0.320	500/1	48	10	121/3	155/3	-	-	-	0.2	84
A1	0.320	500/1	48	30	121/3	155/3	-	-	-	0.0	84
A1	0.320	500/1	48	30	121/3	155/3	-	-	-	0.0	88
A1	0.320	500/1	48	30	121/3	155/3	-	-	-	0.5	90
A1	0.320	500/1	48	30	121/3	155/3	-	-	-	0.1	-
A1	0.342	500/1	48	60	121/3	155/3	318	335	3.1	0.9	-
A1	0.321	500/1	48	60	121/3	155/3	304	324	5.1	1.7	>106
A1	0.320	500/1	48	60	121/3	155/3	-	-	-	1.9	-
A1	0.328	500/1	48	60	121/1	155/4	315	339	2.8	2.1	184
A1	0.320	500/1	48	60	121/3	-	-	-	-	2.6	98
A1	0.329	500/1	48	10	121/6	-	181	228	9.6	0.2	80
A1	0.328	500/1	48	60	121/6	-	316	343	4.2	2.0	-
A1	0.305	500/1	48	60	121/24	-	332	351	5.1	1.9	-
A1	0.311	500/1	48	60	121/24	-	324	349	4.8	2.2	-
A2	0.320	500/1	48	60	121/3	-	-	-	-	2.0	-
A2	0.326	500/1	48	60	121/6	-	372	391	4.9	1.8	>108
A2	0.320	500/1	48	10	121/6	-	-	-	-	1.9	-
A2	0.307	500/1	48	30	121/6	-	353	390	7.3	1.7	104
A2	0.296	500/1	48	30	121/24	-	383	483	6.3	1.3	-
A2	0.322	500/1	48	60	121/24	-	369	392	3.5	1.5	>108
A2	0.325	500/1	48	60	121/24	-	375	395	4.6	1.9	>110
A2	0.320	500/1	48	10	121/3	115/3	-	-	-	0.4	102
A2	0.320	500/1	48	30	121/3	155/3	-	-	-	1.5	-
A2	0.320	500/1	48	30	121/3	155/3	-	-	-	2.0	>108
A2	0.320	500/1	48	30	121/3	155/3	-	-	-	2.4	>108
A2	0.320	500/1	48	30	121/3	155/3	-	-	-	1.5	>112
A2	0.323	500/1	48	60	121/3	155/3	373	395	3.9	2.1	>109
A2	0.320	500/1	48	60	121/3	155/3	-	-	-	2.0	-
A2	0.326	500/1	48	60	121/3	155/3	374	393	6	1.8	108
A2	0.320	500/1	48	60	121/1	155/4	-	-	-	1.5	-
A3	0.325	500/1	48	60	121/24	-	400	501	3.2	2.2	-
A3	0.341	500/1	48	60	121/24	-	473	478	4.3	-	-
A3	0.330	500/1	48	30	121/24	-	418	435	5.3	0.8	-
A3	0.295	500/1	48	10	121/6	-	423	464	8	1.1	-
A3	0.315	500/1	48	30	121/6	-	439	471	7	1.1	-
A3	0.327	500/1	48	60	121/6	-	263	492	3	-	-
A3	0.315	500/1	48	10	121/3	155/3	386	473	10	0.6	-
A3	0.326	500/1	48	30	121/3	155/3	424	448	4.5	0.9	-
A3	0.331	500/1	48	30	121/3	155/3	417	451	5.6	0.9	-
A3	0.348	500/1	48	60	121/3	155/3	467	468	1.2	2.0	-
A3	0.328	500/1	48	60	121/3	155/3	441	454	2.5	1.9	-
A3	0.351	500/1	48	60	121/3	155/3	456	463	3	-	-
A3	0.326	500/1	48	60	121/1	155/4	448	475	5	-	-

Figure 9 demonstrates the effect of cold rolling -alloy 2:

Figures 10(a) and 10(b) demonstrate the effects of secondary artificial ageing on material of alloy 2 with prior cold word (cw) treatment from 0-60%. The alloy of Figure 10(a) has undergone a solution heat treatment of 500°C for 2 hours, 0 hours natural ageing, cold working and united artificial ageing at 1210°C for 3 hours. In Figure 10(c), the alloy has undergone solution heat treatment at 500°C for 2 hours, 48 hours of natural ageing, cold working and an initial artificial ageing at 121°C for 3 hours.

Table 4 demonstrates the response of alloys 1,2 and 3 of Example 2 to varying effects of cold working and artificial ageing.

The column marked C .W. represents the % reduction during a cold working step. The columns AA(1) and AA(2) are expressed in the form T/t where T is the temperature °C of that step of heat treatment and t is the time in hours the material is held at that temperature.

The column marked N. A. represents the natural ageing time. SHT/ANN is the solution heat treatment/annealing temperature and time expressed in the T/t format given for the artificial ageing step [AA(1) and AA(2)]. The remaining columns represent

the properties of yield strength, ultimate tensile strength, elongation, earing and dome reversal pressure respectively.

A number of sheet alloys were formed into cups for body making and the earing levels measured. The cups were then formed into bodies on a can body maker. Each of the example results is from a successful can body free of holes or surface marking. The buckle resistance of selected cans was measured on a conventional buckle resistance testing machine.

From the results the alloys demonstrate a very high tensile strength with ductilities in excess of 4%. The earing levels of can bodies made from the alloy of the invention show earing levels between 0 - 2.4%. These levels are on average 1% lower for a given condition than that of can bodies made from 3004 alloys.

The dome reversal pressures for these cans made from alloys of the invention at the same thickness as cans made from 3004 are far in excess of 3004 values. Dome reversal pressures for cans of 3004 alloy are typically about 90 p.s.i. maximum whereas the cans of the same thickness made from the invention alloys is between 100 and 115 p.s.i.

The graph of Figure 11 illustrates the effect ageing has on the tensile properties of alloys 2 and 3

and Figure 12 shows a comparison between tensile properties for the invention alloys and that of 3004. Figure 12 shows how the invention alloys between lines A and B have tensile strengths about 20 - 40% higher than 3004 type alloys (conventional can stock) with ductilities in excess of 4% and are therefore superior in a number of properties.

A stronger can body material means that the wall thickness of a can body can be reduced whilst maintaining standard 3004 rigidity and buckle resistant.

EXAMPLE 3

As discussed earlier for an alloy to be suitable as can end stock, minimum post bake strength and ductility properties are required.

An alloy with the composition of alloy 3 in Example 2 are subjected to the following processing steps.

1. Hot rolling to 3.0 mm.

2. Cold rolling from 3.0 to 0.8 mm.

3. Anneal at 345°C for 1 hour.

4. The material was sectioned into 2 samples with one sample cold rolled to 0.43 - and the other to 0.355 mm.

5. Both samples were subjected to a solution heat treatment at 500°C for 1 hour before being water quenched.

6. Both samples were then cold rolled to 0.315 mm representing a cold rolling reduction of 30% and 10% respectively.

7. The samples were then sectioned to produce 8 samples and all samples were subjected to natural ageing for 24 hours.

8. The samples were subjected to artificial ageing at 121°C for 3 hours or 6 hours.

9. Half the samples were then baked at 205°C for 20 minutes.

10. Tensile tests and cups were then ed for each sample and the results tabulated in Table 5.

Table 6 illustrates the % drop in strength and ductility properties as a result of a bake used by can end producers.

From the results of Example 3, it can be seen that a can end produced in accordance with the invention has post bake properties which exceed the minimum requirements of strength and ductility.

Present can end stock alloy AA5182 has a yield stress of 325 MPa, ultimate tensile stress of 370 MPa

and an elongation of 8%. It can be seen that post bake properties of can end stock in accordance with the alloy and process of the invention, has properties comparable with conventional can end stock.

TABLE 5

SAMPLE UNITS	ALLOY	HEAT TREAT °C/hrs	REDUCTION (ROLLING) %	POST BAKE °C/mins	YIELD MPa	UTS MPa	ELONGa %
L	A3	121/3	10	-	403	447	9.0
M	A3	121/6	10	-	440	474	8.0
N	A3	121/3	30	-	433	464	7(15)
P	A3	121/6	30	-	464	487	6.5
Q	A3	121/3	10	205/20	334	337	7.0
R	A3	121/6	10	205/20	326	367	7.0
S	A3	121/3	30	205/20	342	376	6.0
T	A3	121/6	30	205/20	335	371	6.5

TABLE 6

PRE AND POST BAKE COMPARISON

HEAT TREAT	ALLOY	REDUCTION	YIELD				U.T.S.				ELONGATION	
			PRE BAKE	POST BAKE	DROP	% DROP	PRE BAKE	POST BAKE	DROP	% DROP	PRE BAKE	POST BAKE
121/3	A3	10	403	334	67	16.7	447	377	79	15.6	9.0	7.0
121/6	A3	10	440	326	14	3.2	474	367	107	22.6	8.0	7.0
121/3	A3	30	433	342	91	21.0	464	376	88	18.9	7(15)	6.0
121/6	A3	30	464	335	129	27.8	487	371	116	23.8	6.5	6.5

Figure 13 basically illustrates the main adantages of the invention over conventional can stock alloys. Cans with comparable strength mean lower cost of alloy from thinner material allowing less material to be consumed to make the same number of cans.

As demonstrated by the Examples, can body can be produced with strength, ductility and anisotropic properties which far exceeds properties obtainable from conventional body stock alloys. As it is possible to also produce can end stock, using the alloy and produced in accordance with the invention, having the necessary properties to produce can ends, a two piece beverage container can be produced from the same alloy type with the same alloy composition.

The claims form part of the disclosure of this specification.

CLAIMS:

1. A process for producing an aluminium can stock from aluminium alloy comprising 3.0 to 8.0 wt% zinc, 0.5 - 3.0 wt% magnesium, less than 0.7 wt% iron, 0.01 - 2.0 wt% silicon, 0.05 - 0.9 wt% copper, 0.1 - 1.1 wt% manganese, less then 0.3 wt% chromium and incidental impurities less than a total of 0.15 wt%, said process comprising the steps of forming melt of tbe alloy metal suitable for casting, casting the melt into a form suitable for rolling, performing an intermediate rolling to an intermediate thickness, treating the alloy material with heat, performing finish rolling by a cold rolling reduction within the range of 2 to 85% and temper heat treating the material to the desired ductility and strength properties.

2. The process in accordance with claim 1 wherein the aluminium alloy has a zirconium level of less than 0.01 wt%.

3. The process in accordance with claim 1 or claim 2 whereby the alloy material has a metal matrix which has an alpha phase dispersed therethrough.

4. The process in accordance with claim 1 or claim 2 wherein the finish rolling step is a cold rolling reduction of between 10 - 80%.

5. The process in accordance with claim 1 or claim 2 wherein the finish rolling step is a cold rolling reduction of 30 - 70%.

6. The process in accordance with claim 1 or claim 2 wherein zinc is present in tbe range of 4 - 6.5 wt%, magnesium 1.0 - 2.5 wt% manganese, 0.3 - 0.8 wt% silicon 0.15 - 0.3 wt%, iron up to 0.45 wt%, copper 0.10 - 0.50 wt% and chromium up to 0.05 wt%.

7. The process in accordance with claim 1 wherein a heat treatment step follows the casting step to homogenise the material.

8. The process in accordance with claim 5 wherein a hot rolling step follows the heat treatment step and precedes the intermediate rolling step.

9. The process in accordance with claim 8 wherein after the hot rolling step the material is hot coiled at a sufficiently high temperature to allow the coiled material to anneal while in the coiled state.

10. The process in accordance with any one of claims 1 - 8 wherein the intermediate rolling step is a cold rolling stage.

11. The process in accordance with claim 7 wherein the intermediate rolling step includes a full anneal or recovery intermediate anneal during the cold rolling stage.

12. The process in accordance with claim 1 where the step of treating the alloy with heat is a solution heat treatment.

13. An aluminium can stock produced from an alloy having 3.0 - 8.0 wt% zinc, 0.5 - 3.0 wt% magnesium less then 0.7 wt% iron, 0.01 - 2.0 wt%

silicon, 0.05 - 0.9 wt% copper, 0.1 - 1.1 wt% manganese, less then 0.3 wt% chromium and incidental impurities less then a total of 0.15 wt%.

14. An aluminium can stock in accordance with claim 13 wherein the zinc composition is in the range of 4 - 6.5 wt%.

15. An aluminium can stock in accordance with claim 13 wherein the magnesium composition is in the range of 1.0 - 2.5 wt%.

16. An aluminium can stock in accordance with claim 13 wherein the manganese composition is in the range of 0.3 - 0.8 wt%.

17. An aluminium can stock in accordance with claim 13 wherein the silicon content is in the range of 0.15 - 0.3 wt%.

18. An aluminium can stock in accordance with claim 13 wherein iron content is less than 0.45 wt%.

19. An aluminium can stock in accordance with claim 13 wherein copper is in the range of 0.10 - 0.50 wt%

20. An aluminium can stock in accordance with claim 13 wherein chromium is in the range of less than 0.05 wt%.

21. An aluminium can stock in accordance with claim 13 wherein zirconium is present in an amount less than 0.01 wt% and zirconium is the range of less than 0.08 wt%.

22. The aluminium can stock in accordance with claim 13 wherein zinc is present in the range 4 - 6.5 wt%, magnesium 1.0 - 2.5 wt%, manganese 0.3 - 0.8 wt%, silicon 0.15 - 0.30 wt%, iron less than 0.45 wt%, copper 0.10 - 0.50 wt%, chromium less than 0.05 wt% and zirconium less than 0.01 wt%.

23. An aluminium can stock in accordance with any one of claims 13 - 21 wherein the alloy material is formed in a melt and cast into a form suitable for rolling, the material then undergoes intermediate rolling to an intermediate thickness before being treated with heat, a finish rolling is then performed on the material by a cold rolling reduction within the range of 2 to 85% and then the material is temper heat treated to the desired ductility and strength.

24. The aluminium can stock in accordance with claim 23 wherein the finish rolling reduction is in the range of 10 to 80%.

25. The aluminium can stock in accordance with claim 23 wherein the finish rolling reduction is in the range of 30 to 70%.

26. A two piece beverage container comprising a body portion and an end portion, said body portion and said end portion being produced from the can stock in accordance with any one of claims 23 - 25.

27. A two piece beverage container, comprising a body portion and an end portion wherein the can stock for both said body portion and said portion

wherein the can stock for both said body portion and said end portion is produced by the process in accordance with any one of claims 1 to 12.

28. A two piece beverage container in accordance with claim 26 wherein said container has a dome reversal of above about 100 psi.

29. A can body produced by deep drawing the can stock of any one of the claims 23 - 25 having an average earing level of less than 2%.

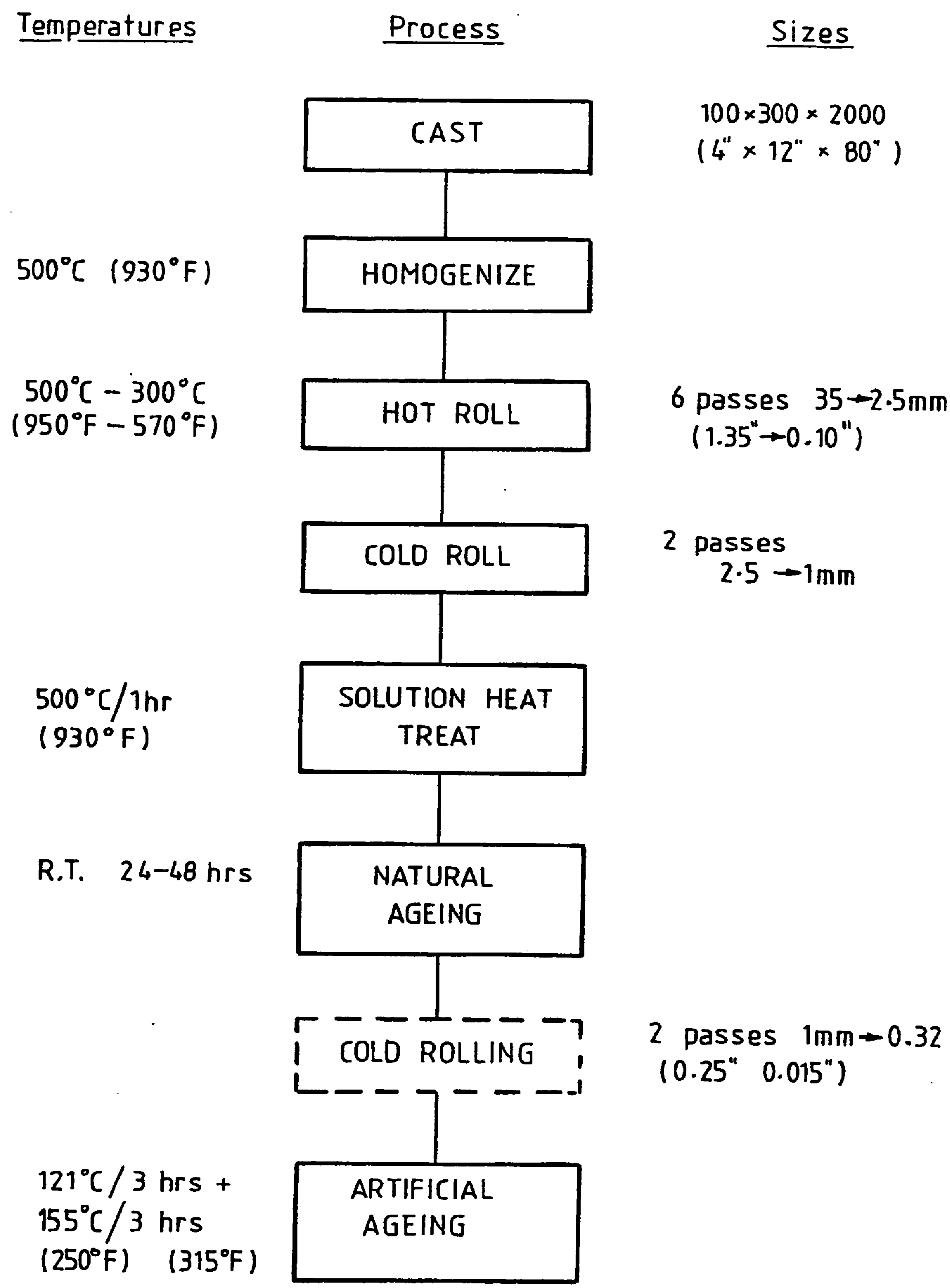
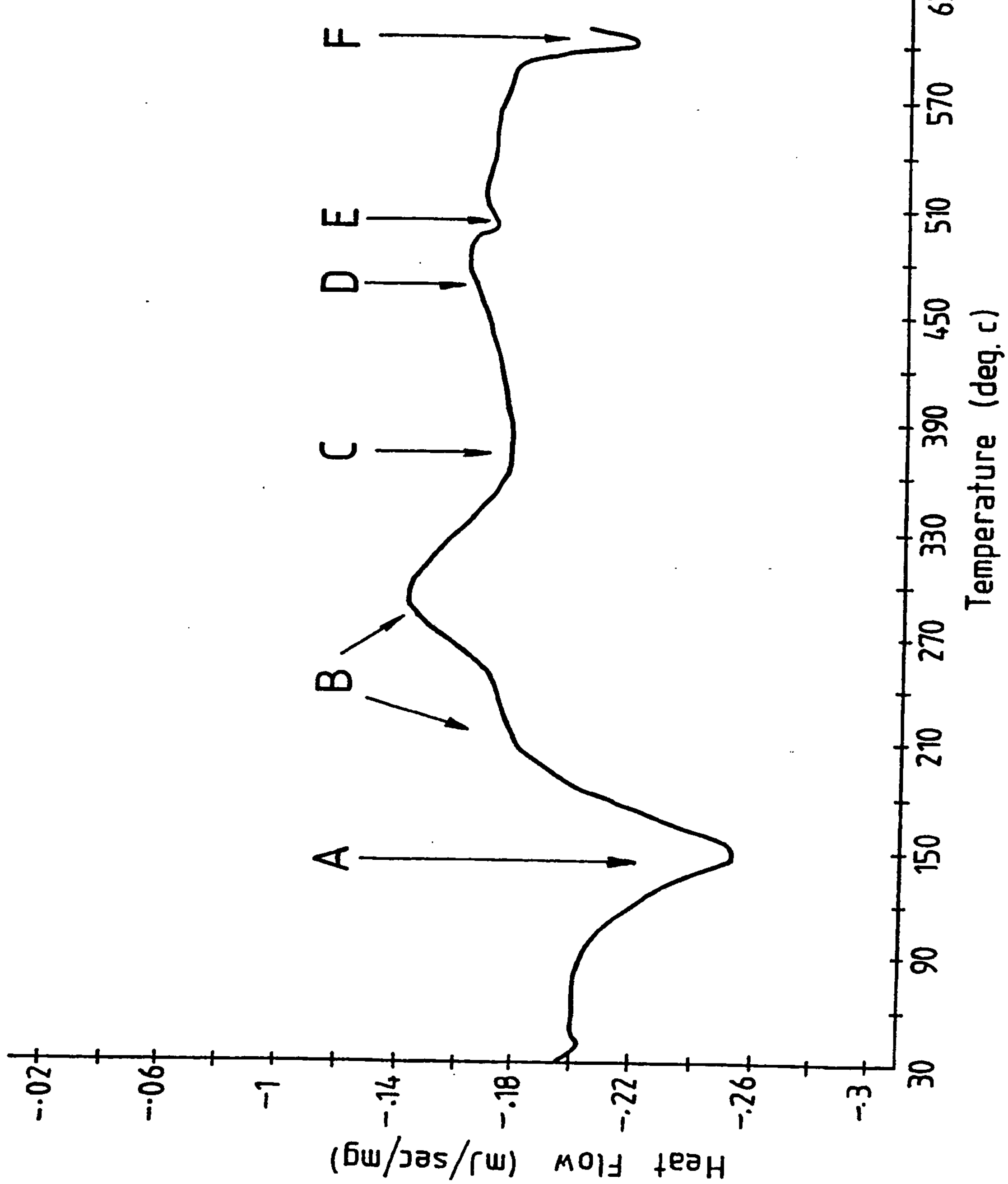

Temperatures
Process
Sizes
CAST
100×300 × 2000
(4" × 12" × 80")
500°C (930°F)
HOMOGENIZE
500°C – 300°C
(950°F – 570°F)
HOT ROLL
6 passes 35→2.5mm
(1.35"→0.10")
COLD ROLL
2 passes
2.5 →1mm
500°C/1hr
(930°F)
SOLUTION HEAT TREAT
R.T. 24–48 hrs
NATURAL AGEING
COLD ROLLING
2 passes 1mm→0.32
(0.25" 0.015")
121°C/3 hrs +
155°C/3 hrs
(250°F) (315°F)
ARTIFICIAL AGEING

FIG. 1.

FIG. 2.


A
B
C
D
E
F
Heat Flow (mJ/sec/mg)
-.02
-.06
-.1
-.14
-.18
-.22
-.26
-.3
30
90
150
210
270
330
390
450
510
570
630
690
Temperature (deg. c)

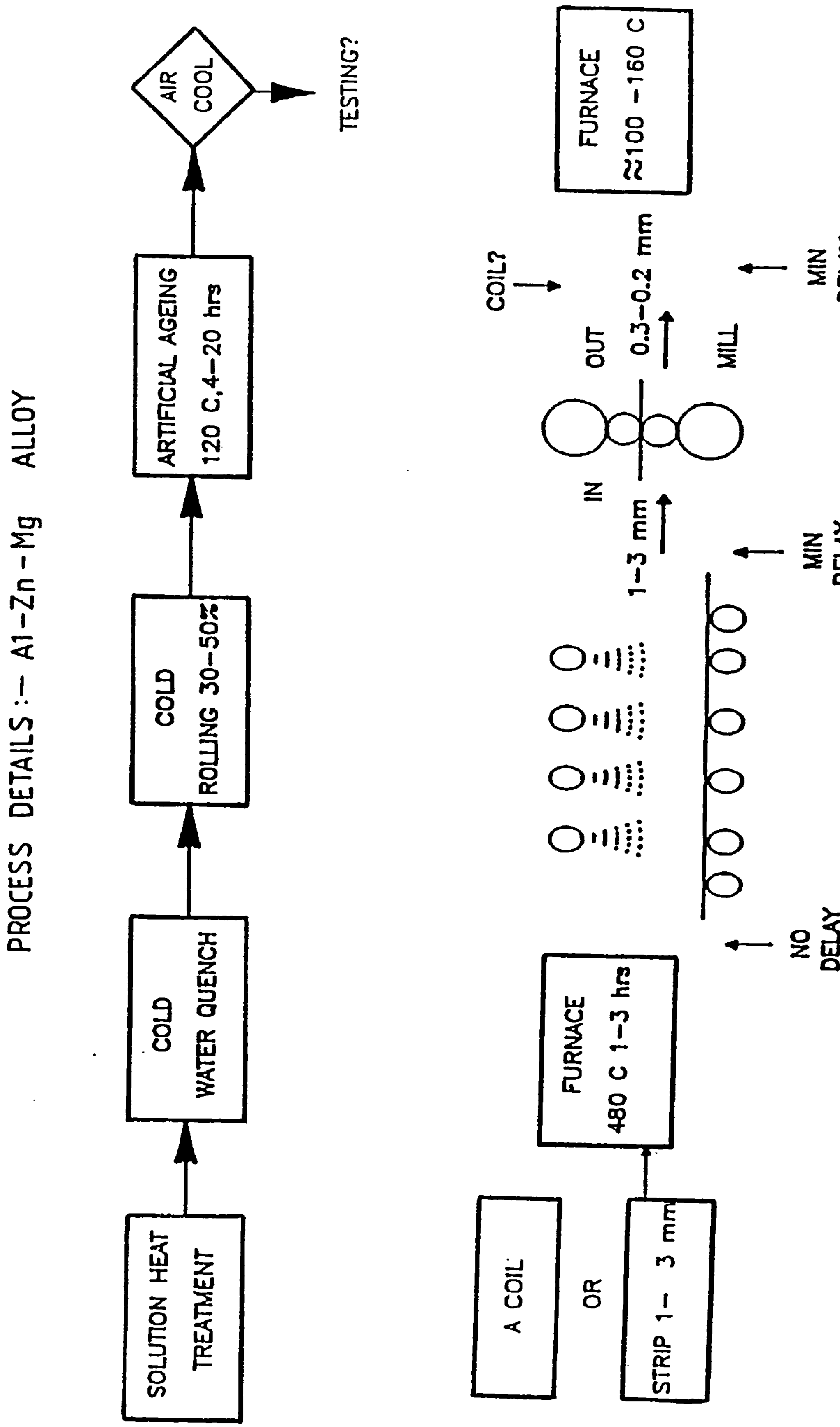

PROCESS DETAILS :— Al–Zn–Mg ALLOY
SOLUTION HEAT TREATMENT
COLD WATER QUENCH
COLD ROLLING 30–50%
ARTIFICIAL AGEING 120 C,4–20 hrs
AIR COOL
TESTING?
A COIL
OR
STRIP 1– 3 mm
FURNACE 480 C 1–3 hrs
NO DELAY
MIN DELAY
1–3 mm
IN
OUT
0.3–0.2 mm
MILL
MIN DELAY
COIL?
FURNACE ≈100 –160 C

FIG. 3a.

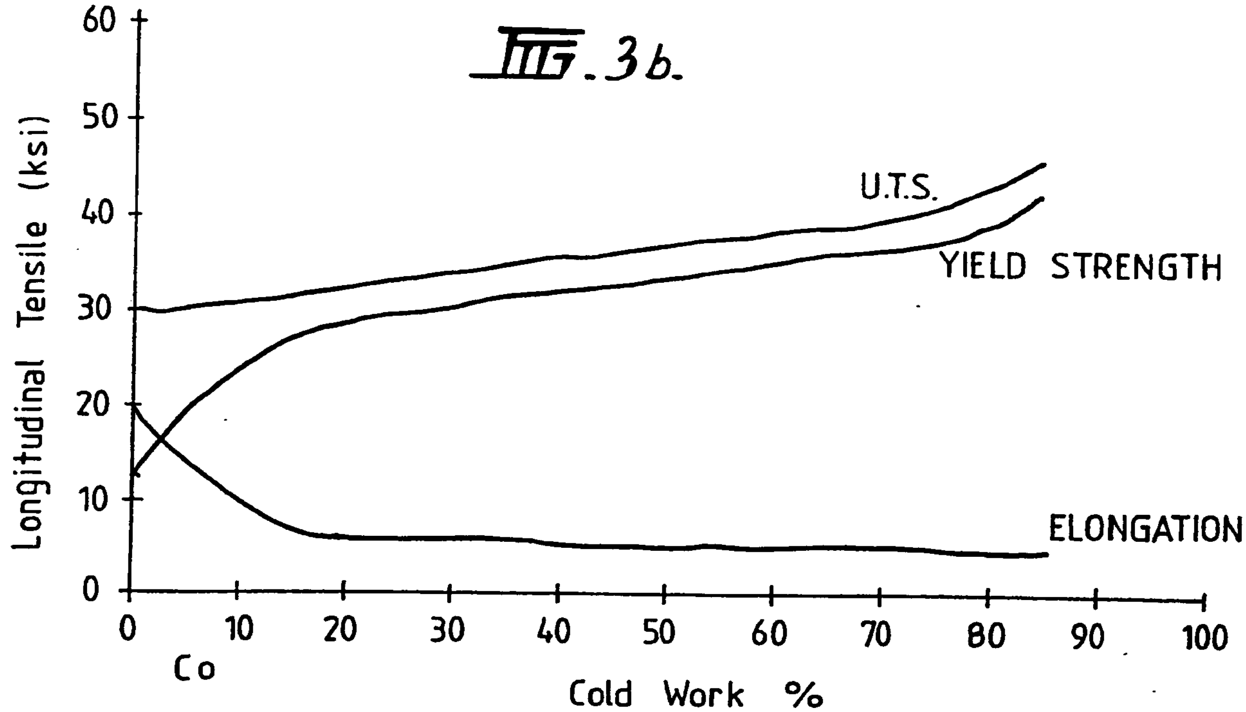

60
50
40
30
20
10
0
Longitudinal Tensile (ksi)
U.T.S.
YIELD STRENGTH
ELONGATION
0
10
20
30
40
50
60
70
80
90
100
Co
Cold Work %

FIG. 3b.

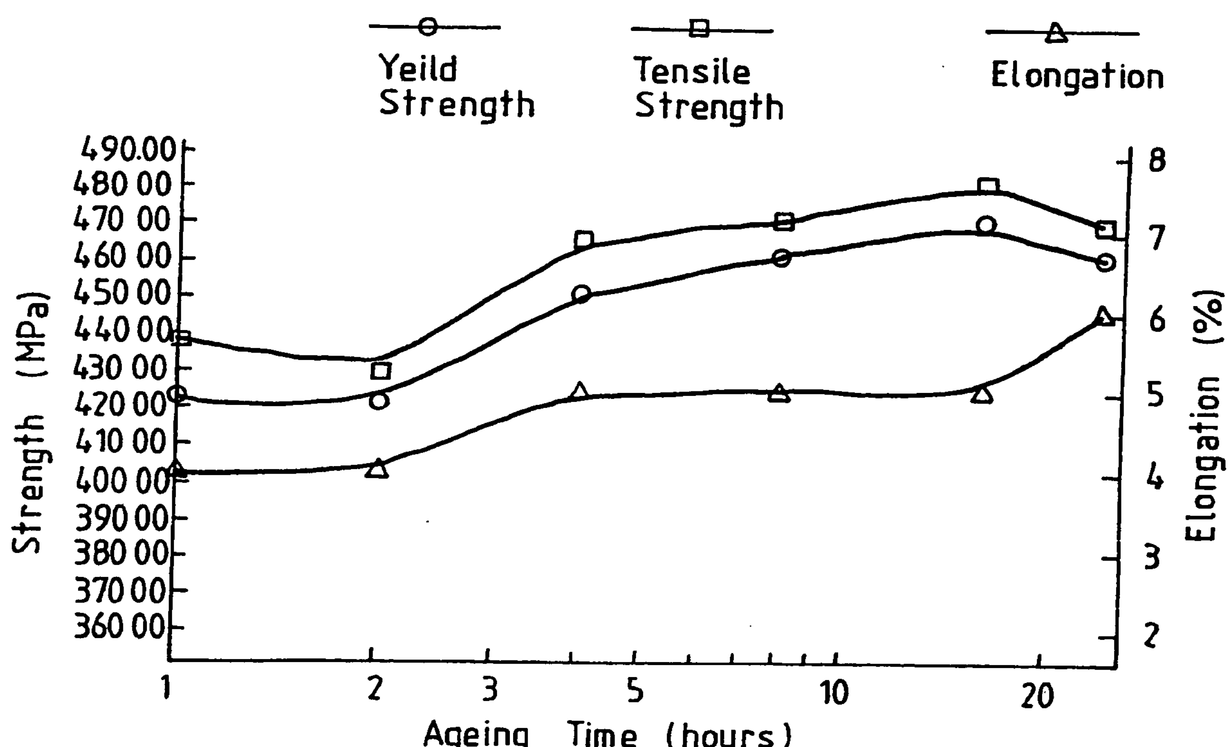
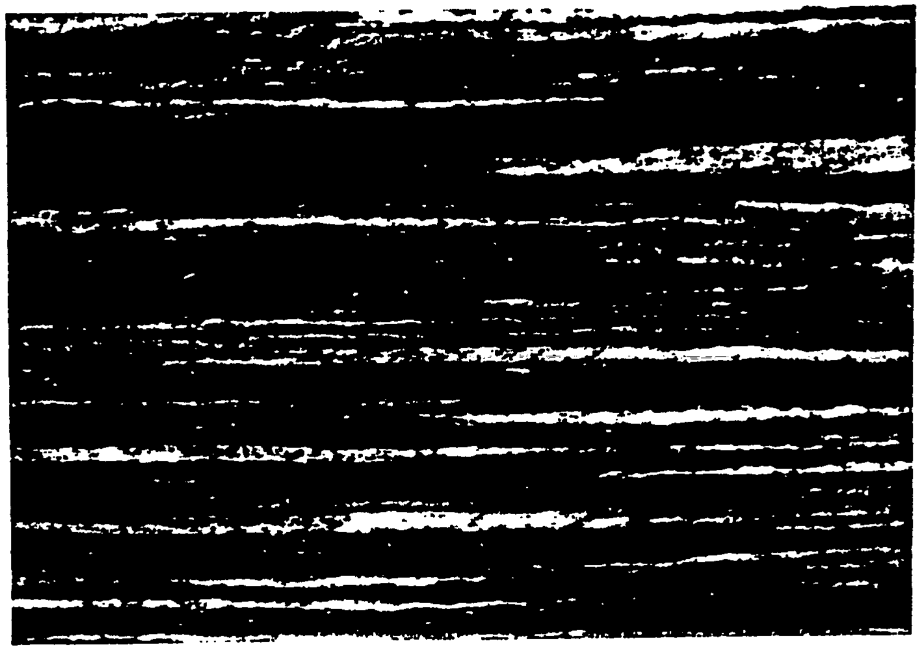

Yeild Strength
Tensile Strength
Elongation
490.00
480 00
470 00
460 00
450 00
440 00
430 00
420 00
410 00
400 00
390 00
380 00
370 00
360 00
Strength (MPa)
8
7
6
5
4
3
2
Elongation (%)
1
2
3
5
10
20
Ageing Time (hours)

FIG. 3c.



Hot Rolled Microstructure, x 200

FIG. 4a.

MICROSTRUCTURES OF ALLOY 2

Anneal 345°C for 1 Hour, x 200

FIG. 4b.

MICROSTRUCTURES OF ALLOY 2

Finished Cansheet Showing
Alpha Phase Dispersion

FIG. 4c.
MICROSTRUCTURES OF ALLOY 2

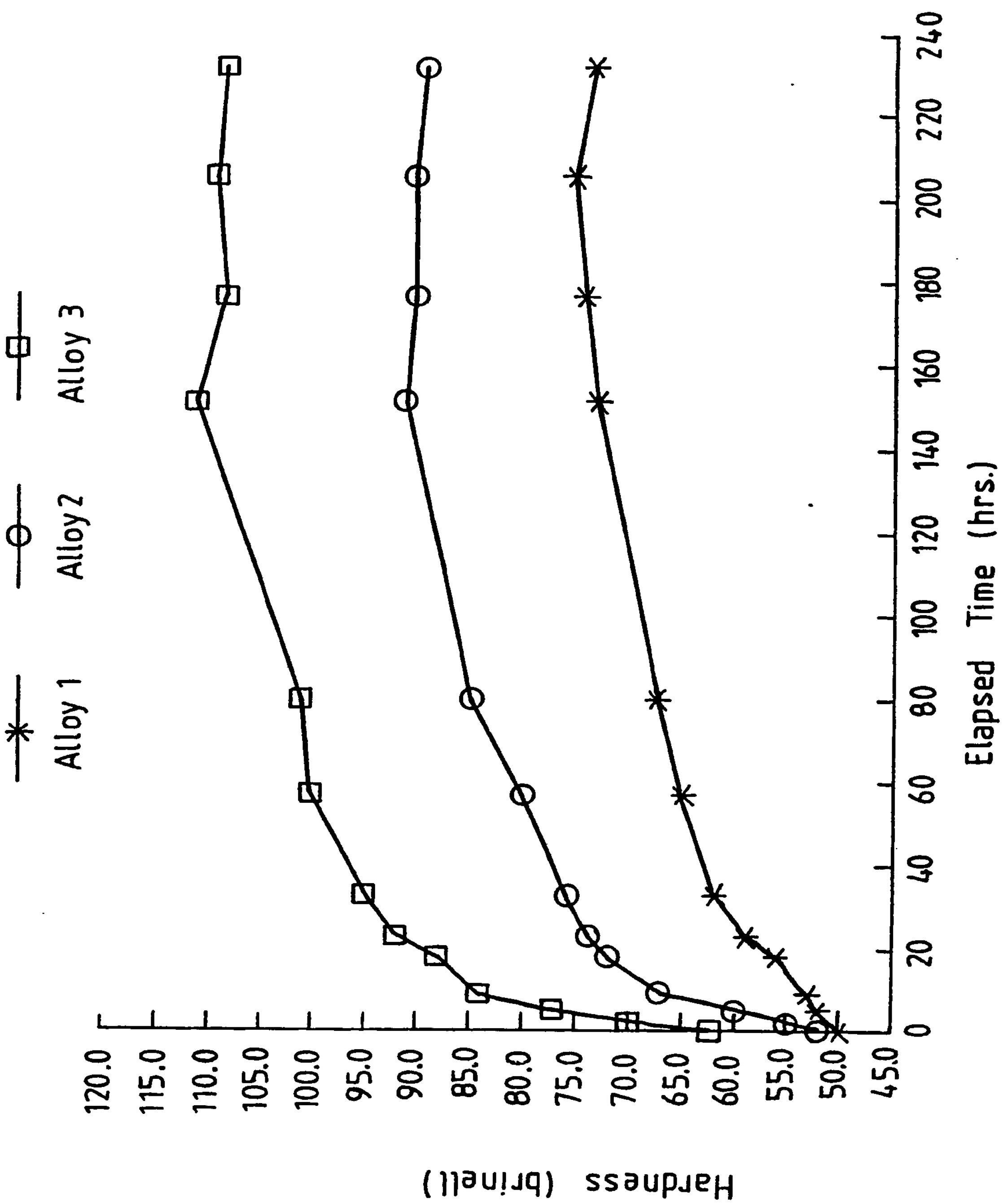

Alloy 1
Alloy 2
Alloy 3
Hardness (brinell)
120.0
115.0
110.0
105.0
100.0
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
0
20
40
60
80
100
120
140
160
180
200
220
240
Elapsed Time (hrs.)

FIG. 5.

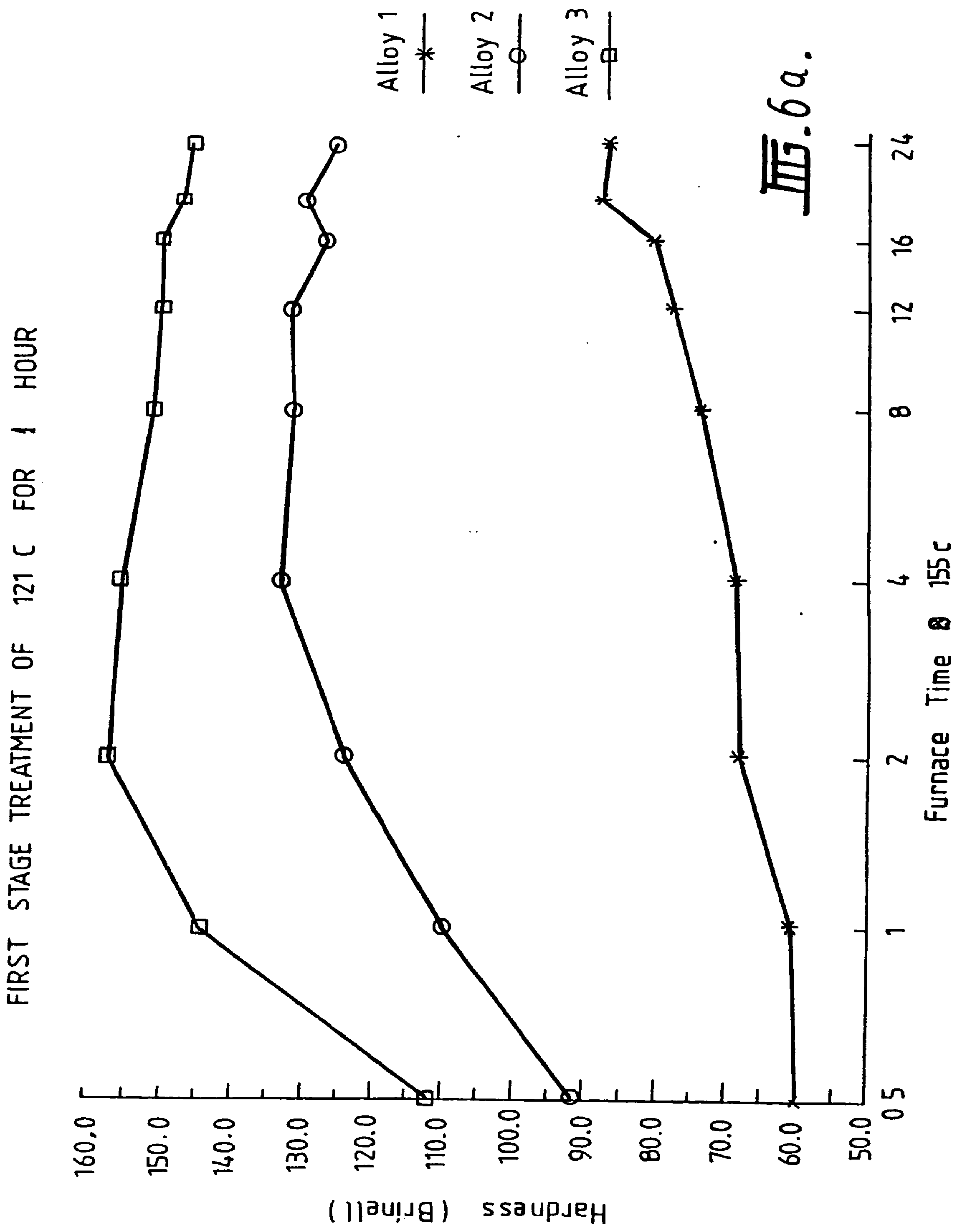

FIRST STAGE TREATMENT OF 121 C FOR 1 HOUR
Alloy 1
Alloy 2
Alloy 3
Hardness (Brinell)
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
0.5
1
2
4
8
12
16
24
Furnace Time @ 155c

FIG. 6a.

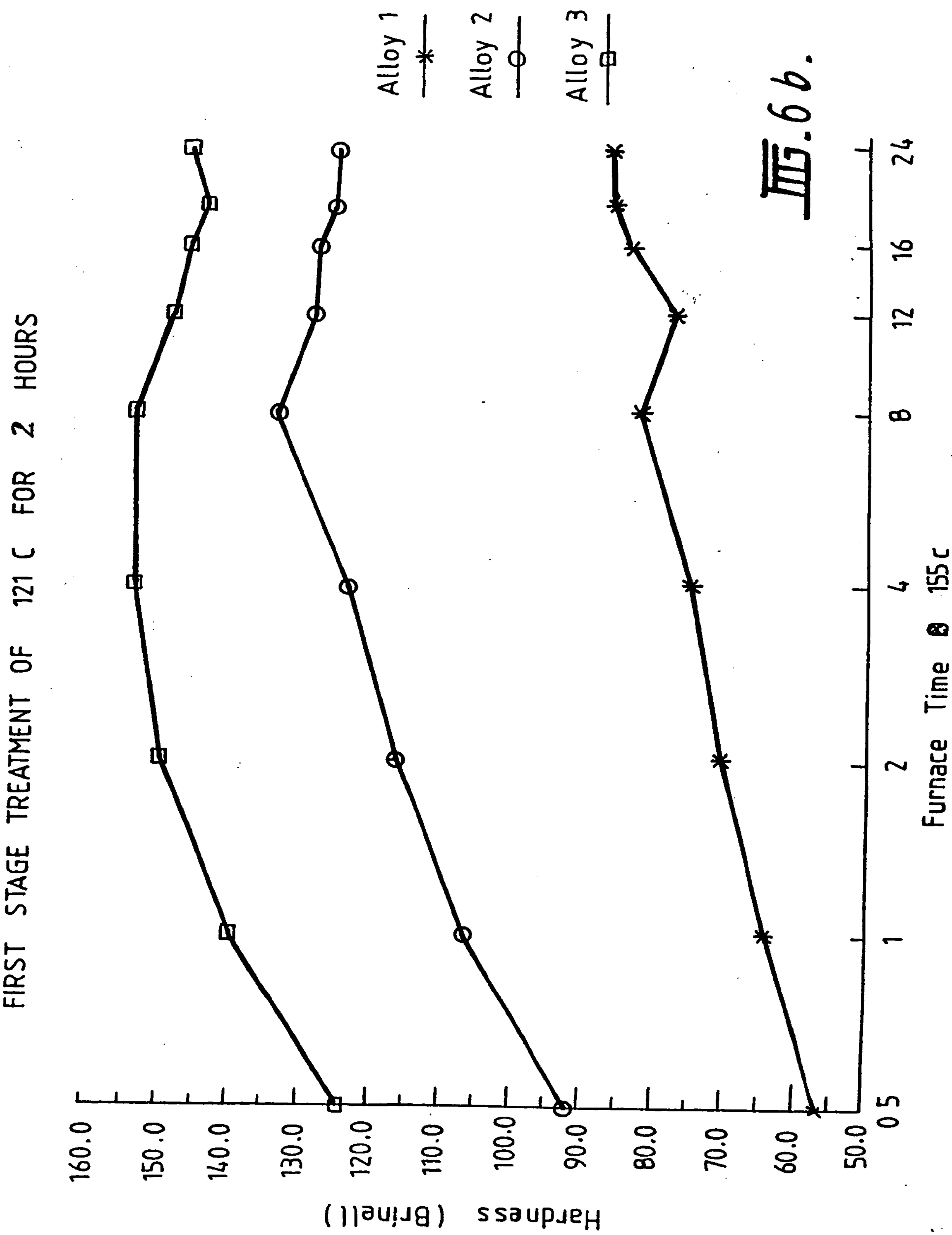

FIRST STAGE TREATMENT OF 121 C FOR 2 HOURS
Alloy 1
Alloy 2
Alloy 3
Hardness (Brinell)
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
0
.5
1
2
4
8
12
16
24
Furnace Time @ 155c

FIG. 6b.

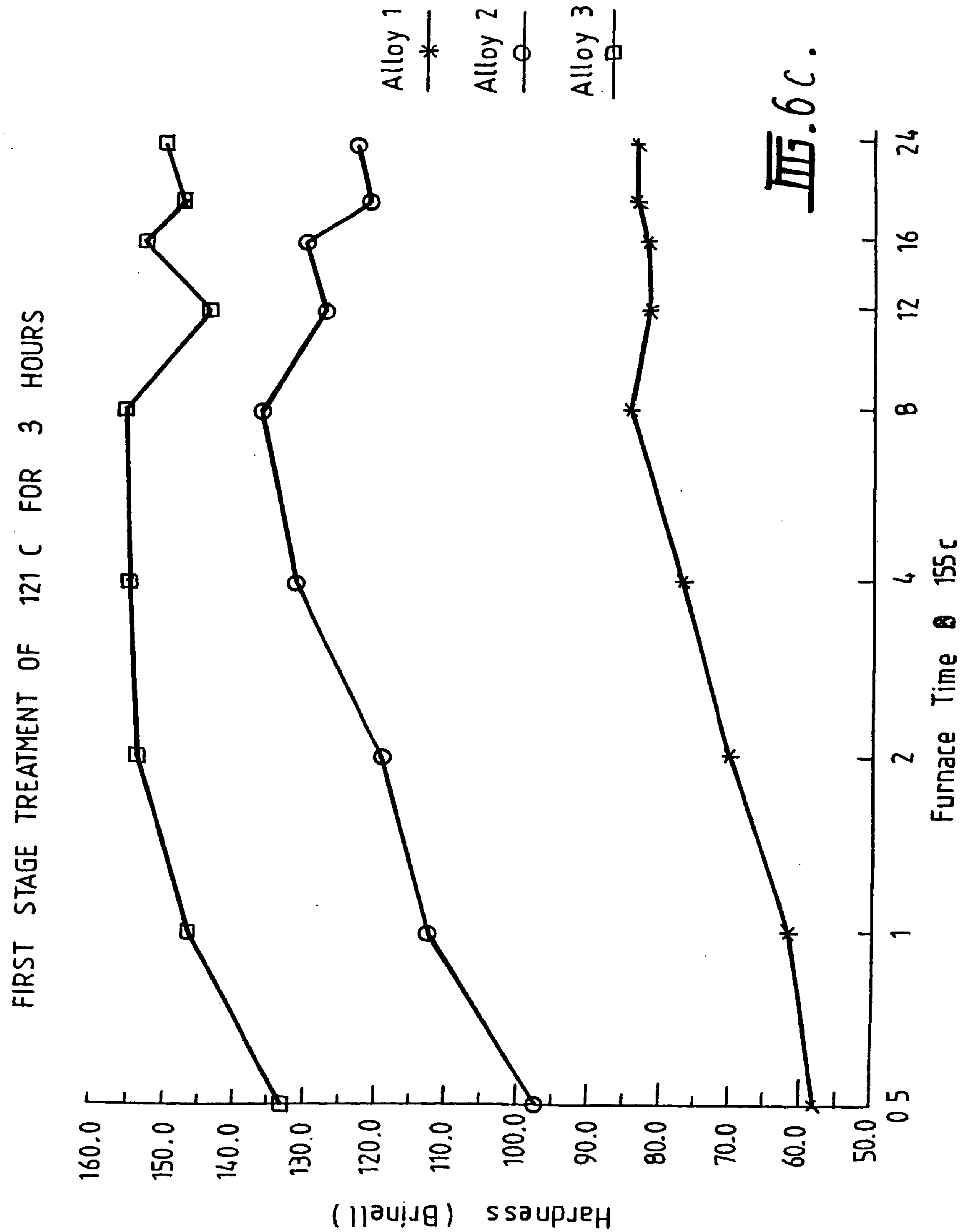

FIRST STAGE TREATMENT OF 121 C FOR 3 HOURS
Hardness (Brinell)
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
0.5
1
2
4
8
12
16
24
Furnace Time @ 155 c
Alloy 1
Alloy 2
Alloy 3

FIG. 6C.

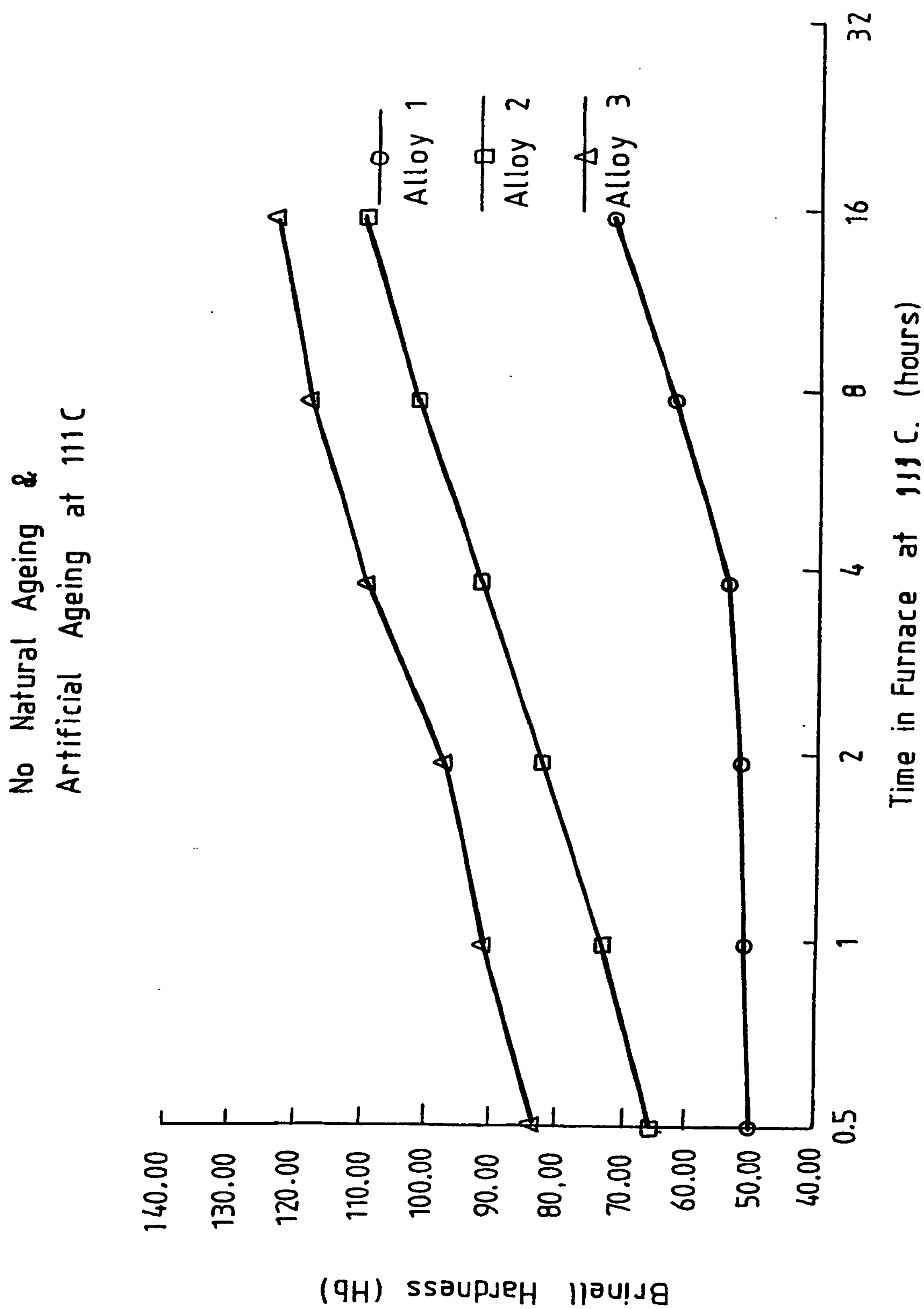

No Natural Ageing &
Artificial Ageing at 111 C
Alloy 1
Alloy 2
Alloy 3
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
Brinell Hardness (Hb)
0.5
1
2
4
8
16
32
Time in Furnace at 111 C. (hours)

FIG. 7a.

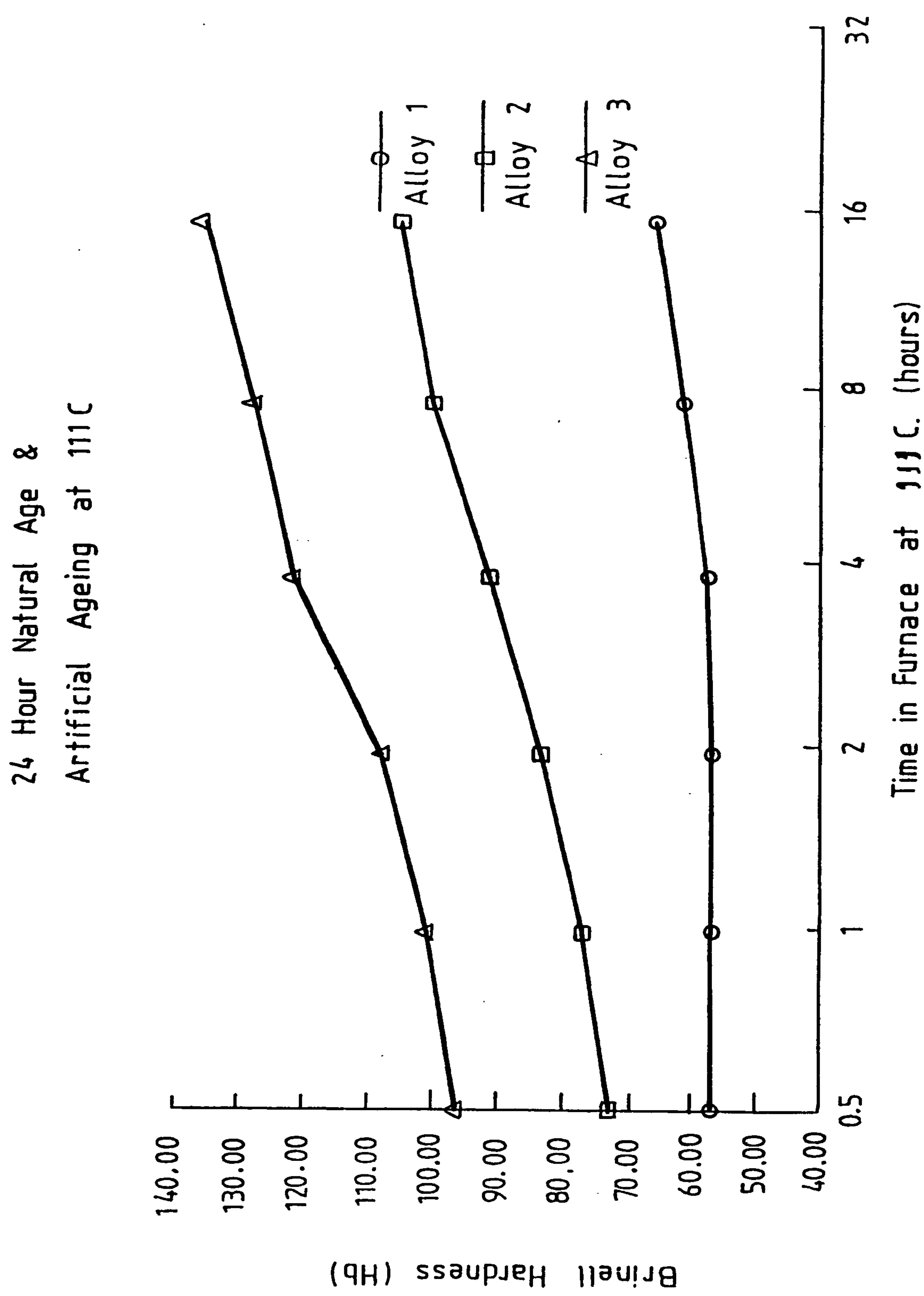

24 Hour Natural Age &
Artificial Ageing at 111 C
Brinell Hardness (Hb)
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
0.5
1
2
4
8
16
32
Time in Furnace at 111 C. (hours)
Alloy 1
Alloy 2
Alloy 3

FIG. 7b.

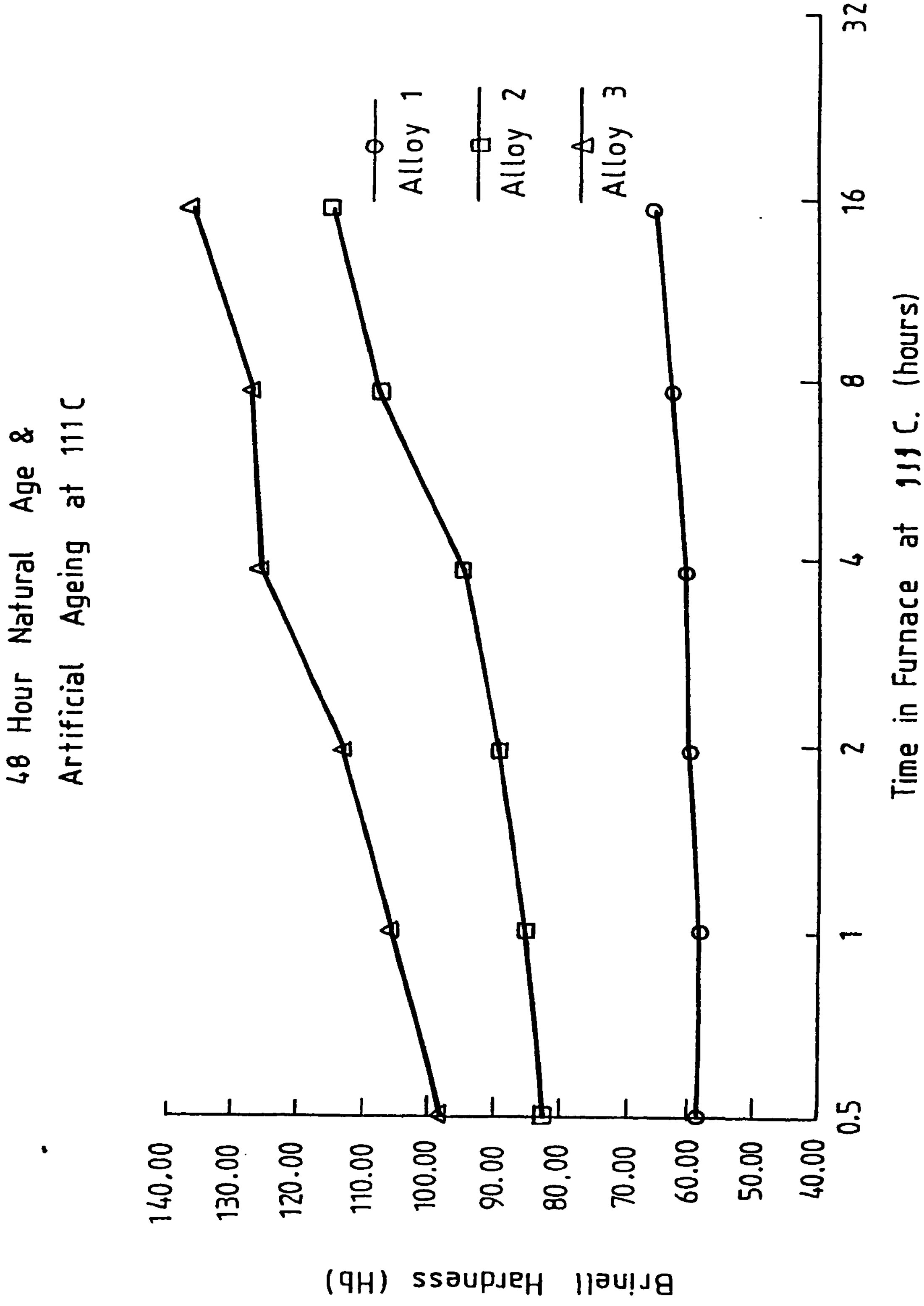

48 Hour Natural Age &
Artificial Ageing at 111 C
Alloy 1
Alloy 2
Alloy 3
Brinell Hardness (Hb)
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
0.5
1
2
4
8
16
32
Time in Furnace at 111 C. (hours)

FIG. 7C

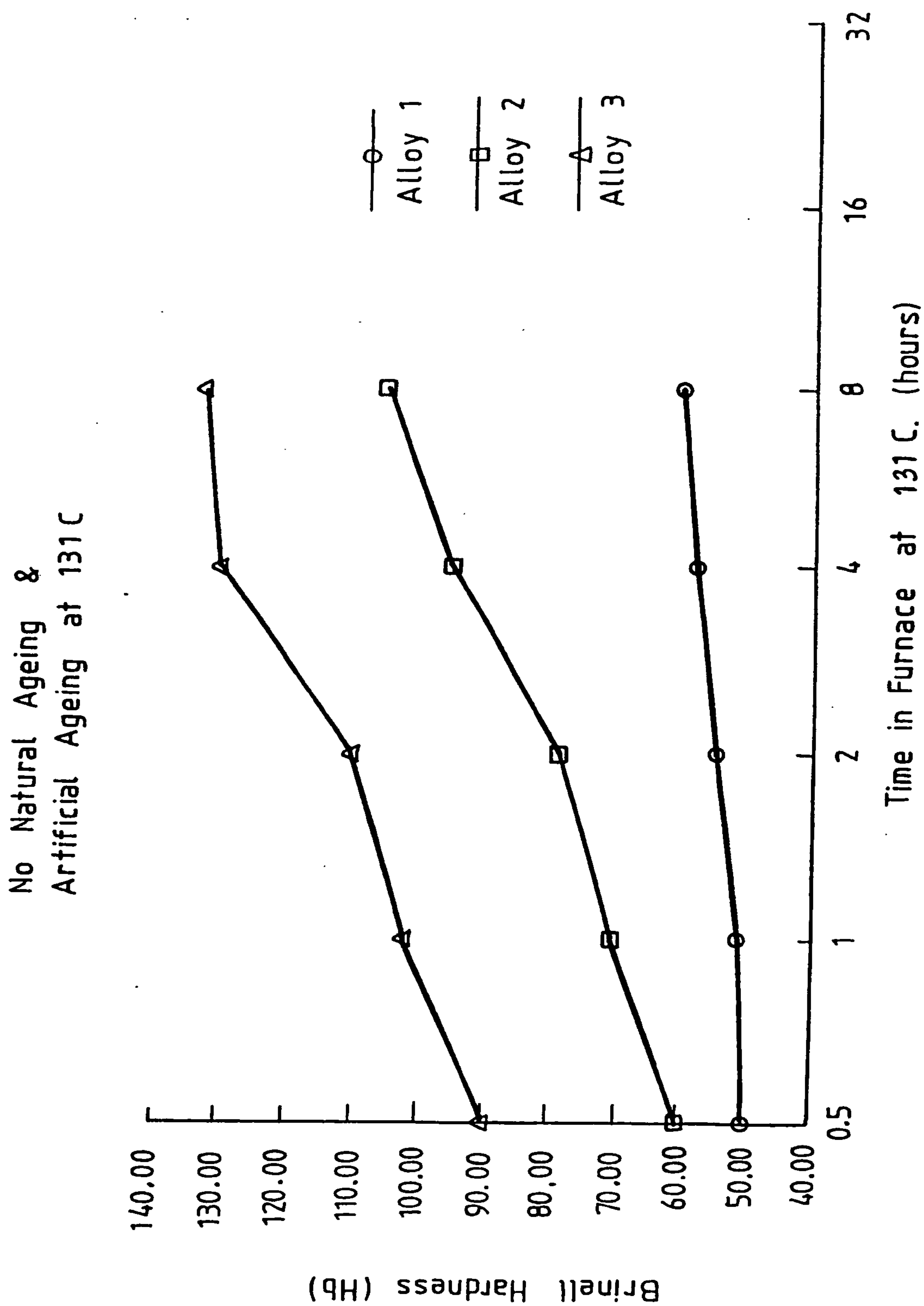

No Natural Ageing &
Artificial Ageing at 131 C
Brinell Hardness (Hb)
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
0.5
1
2
4
8
16
32
Time in Furnace at 131 C. (hours)
Alloy 1
Alloy 2
Alloy 3

FIG. 8a

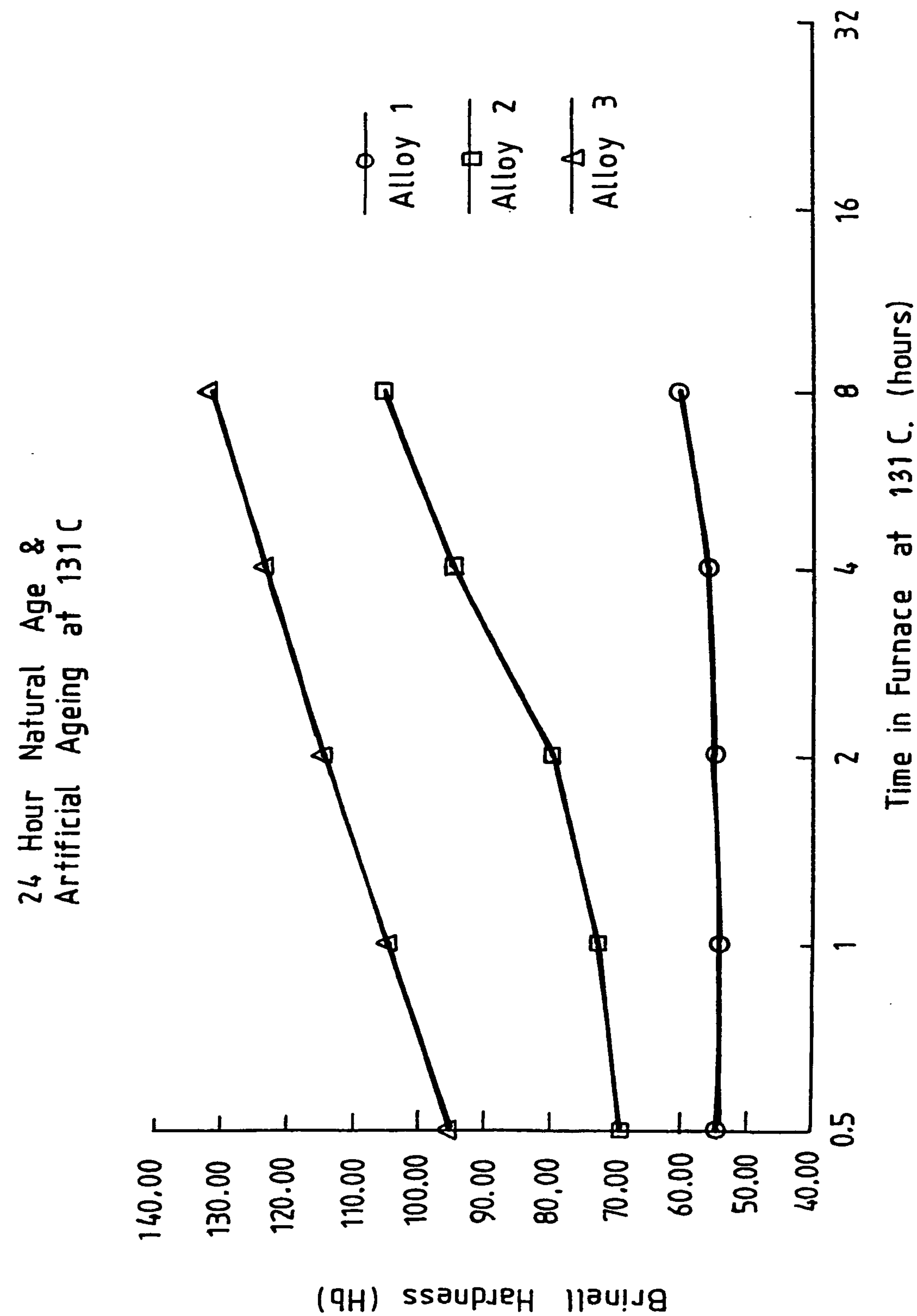

24 Hour Natural Age &
Artificial Ageing at 131 C
Brinell Hardness (Hb)
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
0.5
1
2
4
8
16
32
Time in Furnace at 131 C. (hours)
Alloy 1
Alloy 2
Alloy 3

FIG. 8b.

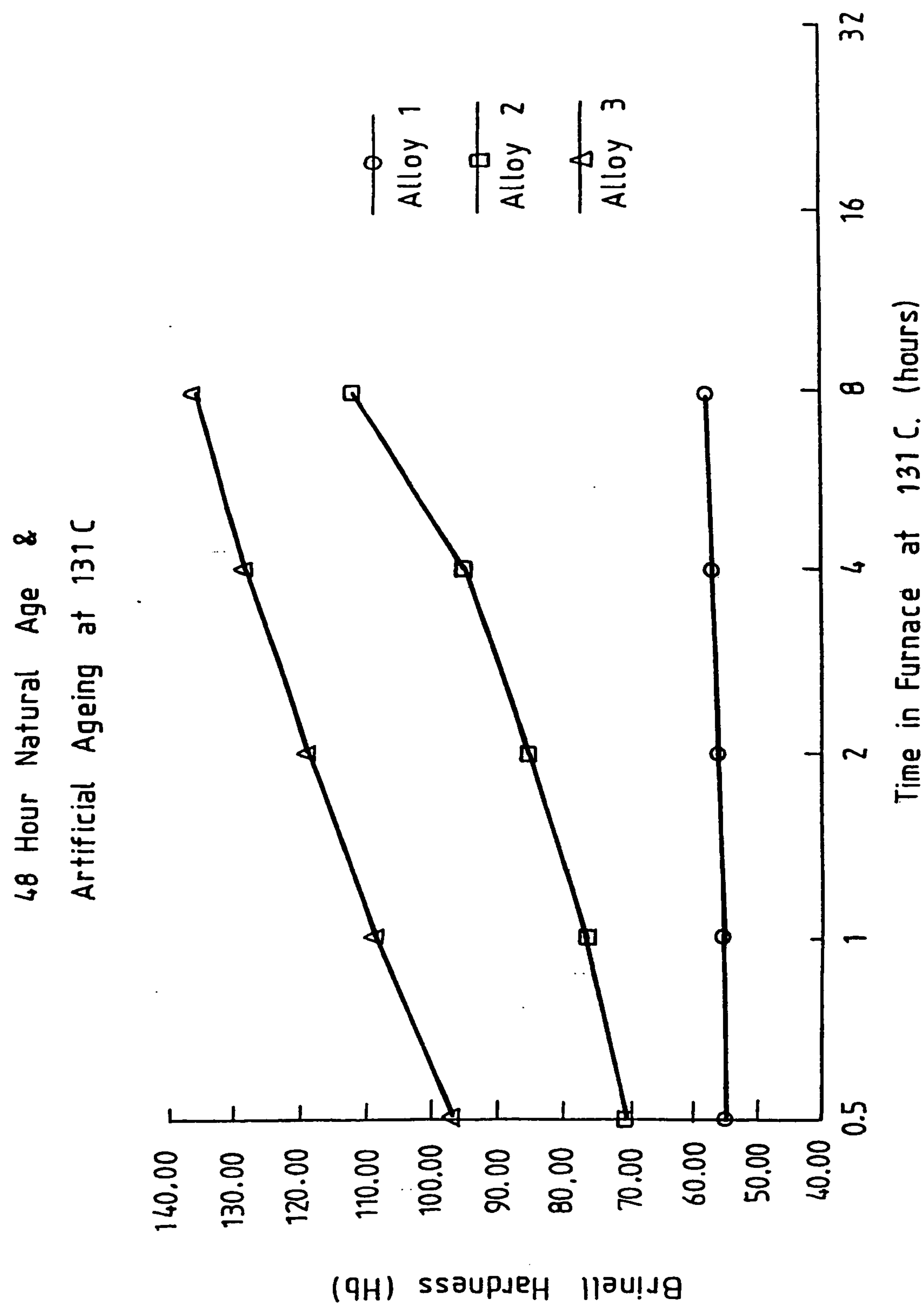

48 Hour Natural Age &
Artificial Ageing at 131 C
Brinell Hardness (Hb)
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
0.5
1
2
4
8
16
32
Time in Furnace at 131 C. (hours)
Alloy 1
Alloy 2
Alloy 3

FIG. 8C

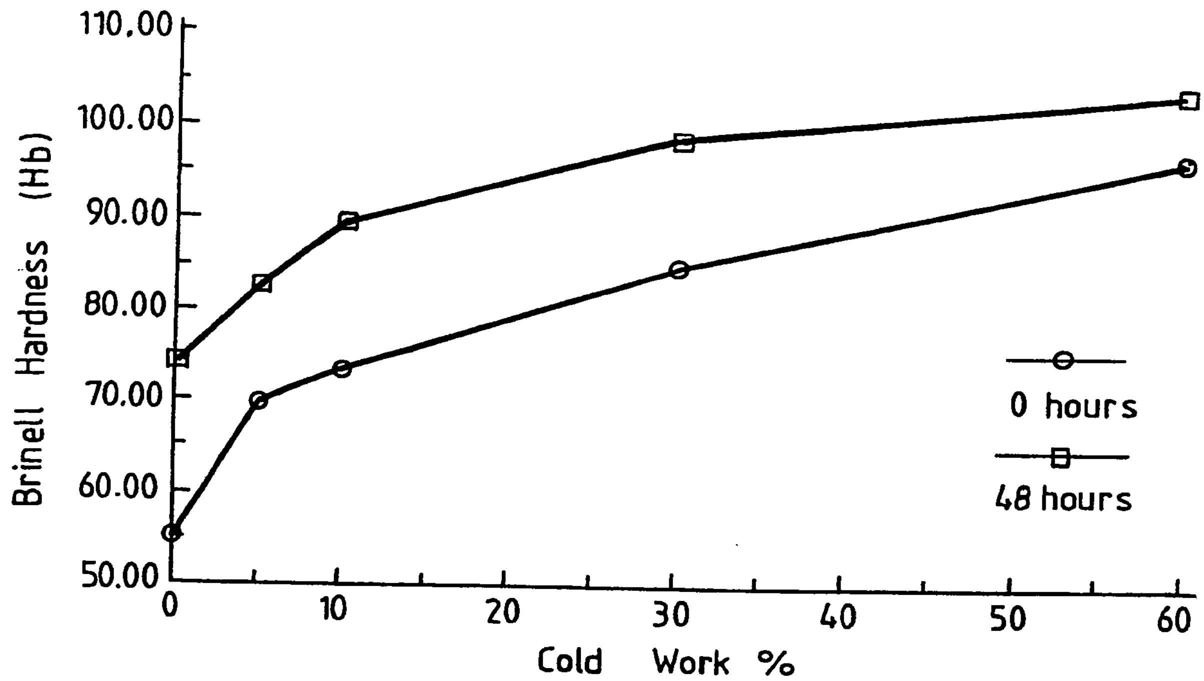

110.00
100.00
90.00
80.00
70.00
60.00
50.00
Brinell Hardness (Hb)
0
10
20
30
40
50
60
Cold Work %
0 hours
48 hours

FIG. 9.

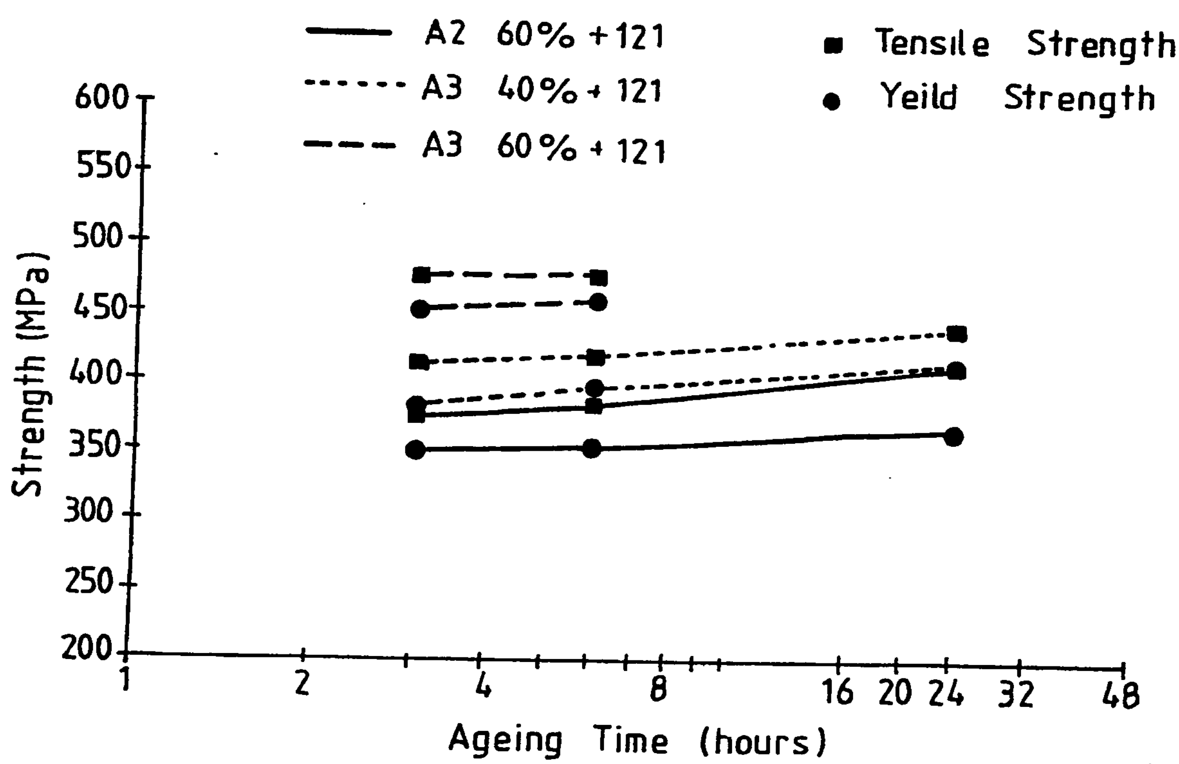

A2 60% + 121
A3 40% + 121
A3 60% + 121
Tensile Strength
Yeild Strength
600
550
500
450
400
350
300
250
200
Strength (MPa)
1
2
4
8
16
20
24
32
48
Ageing Time (hours)

FIG. 11.

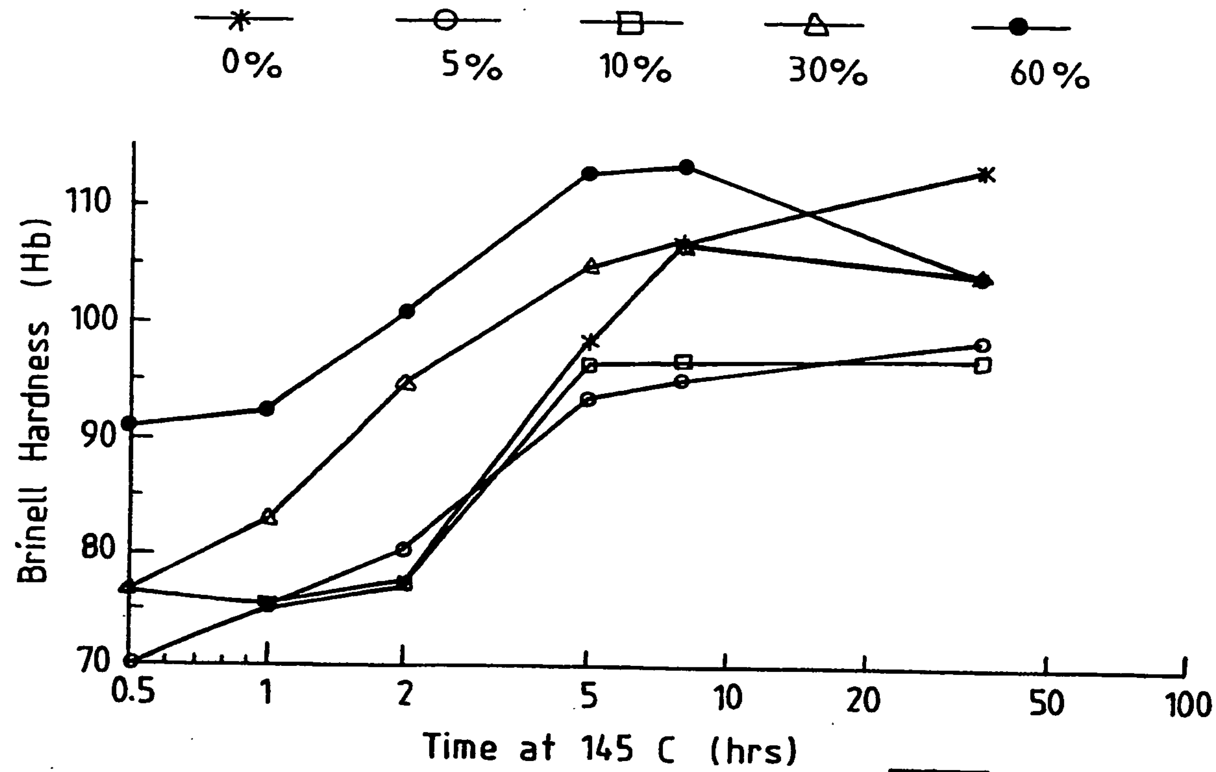


FIG. 10a.

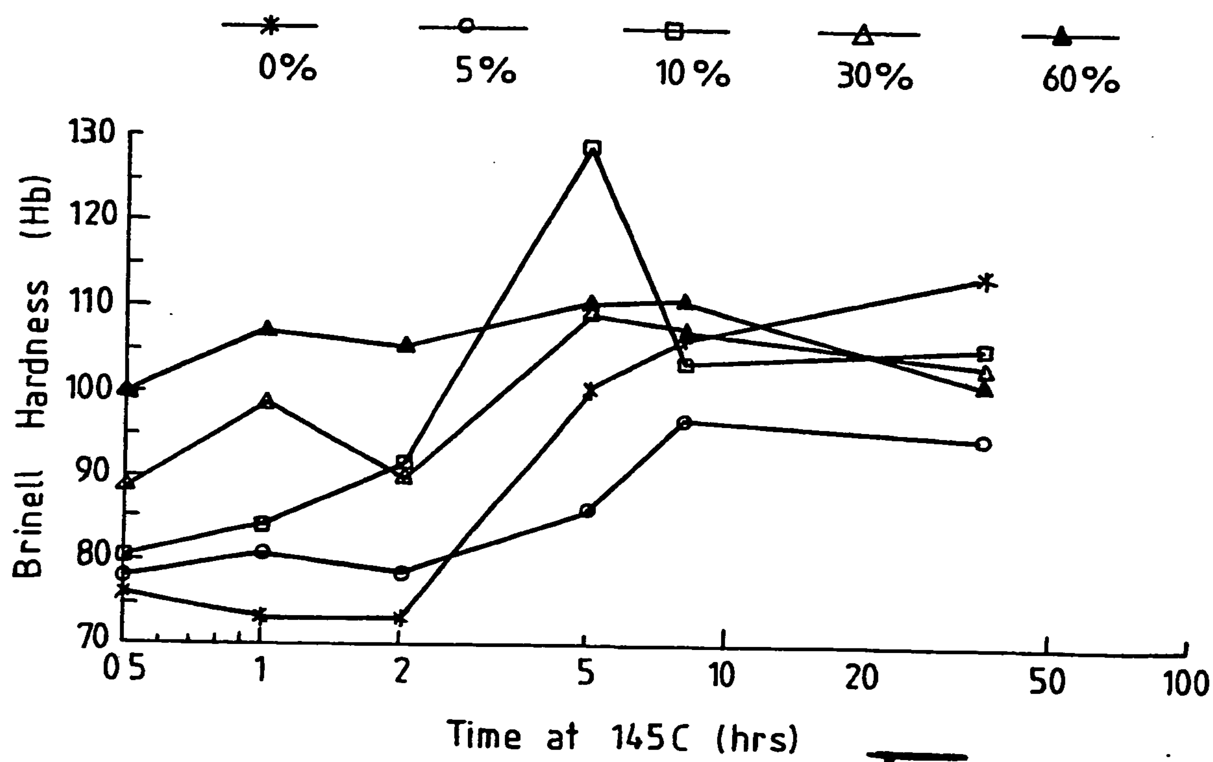


FIG. 10b.

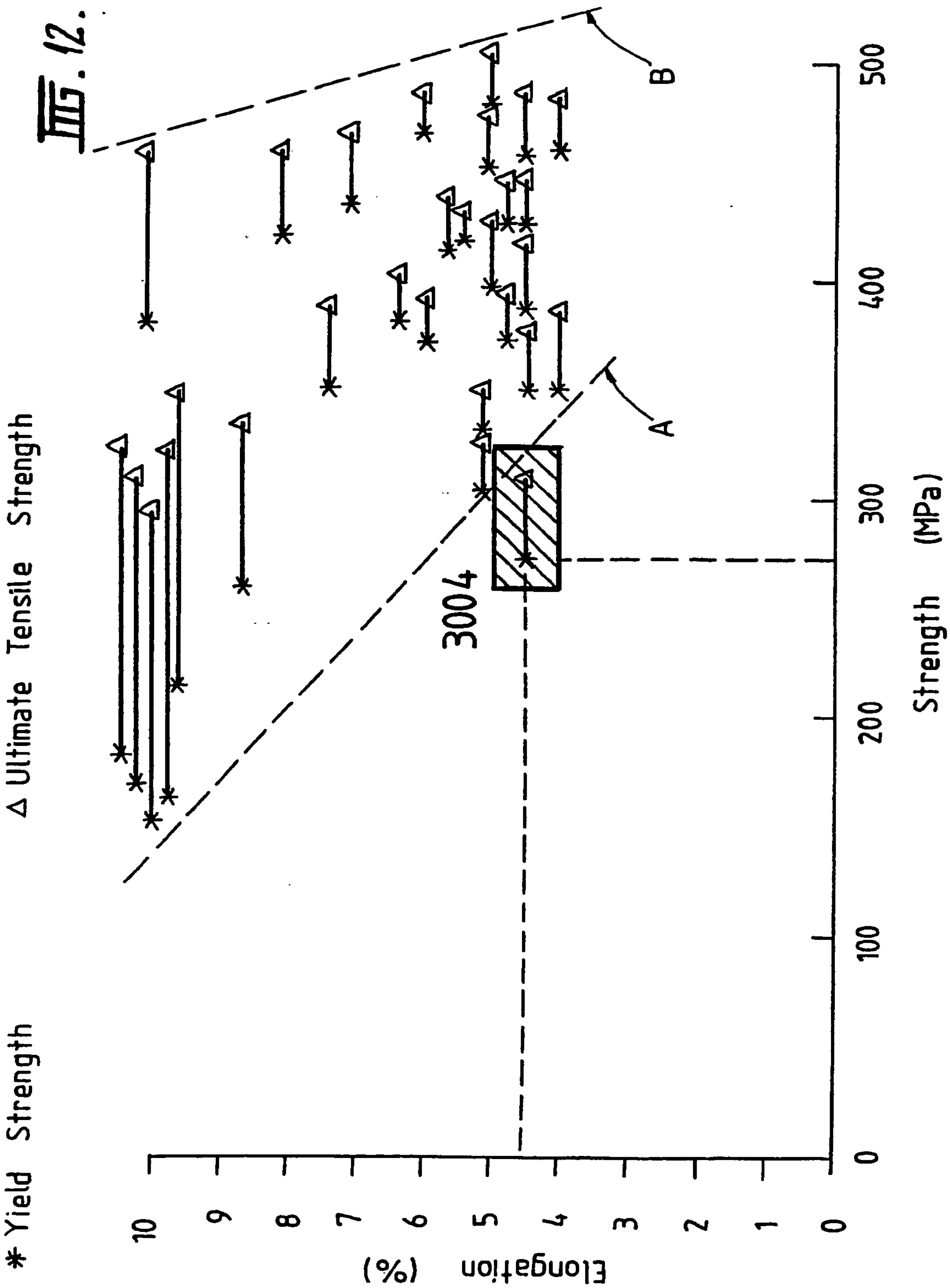
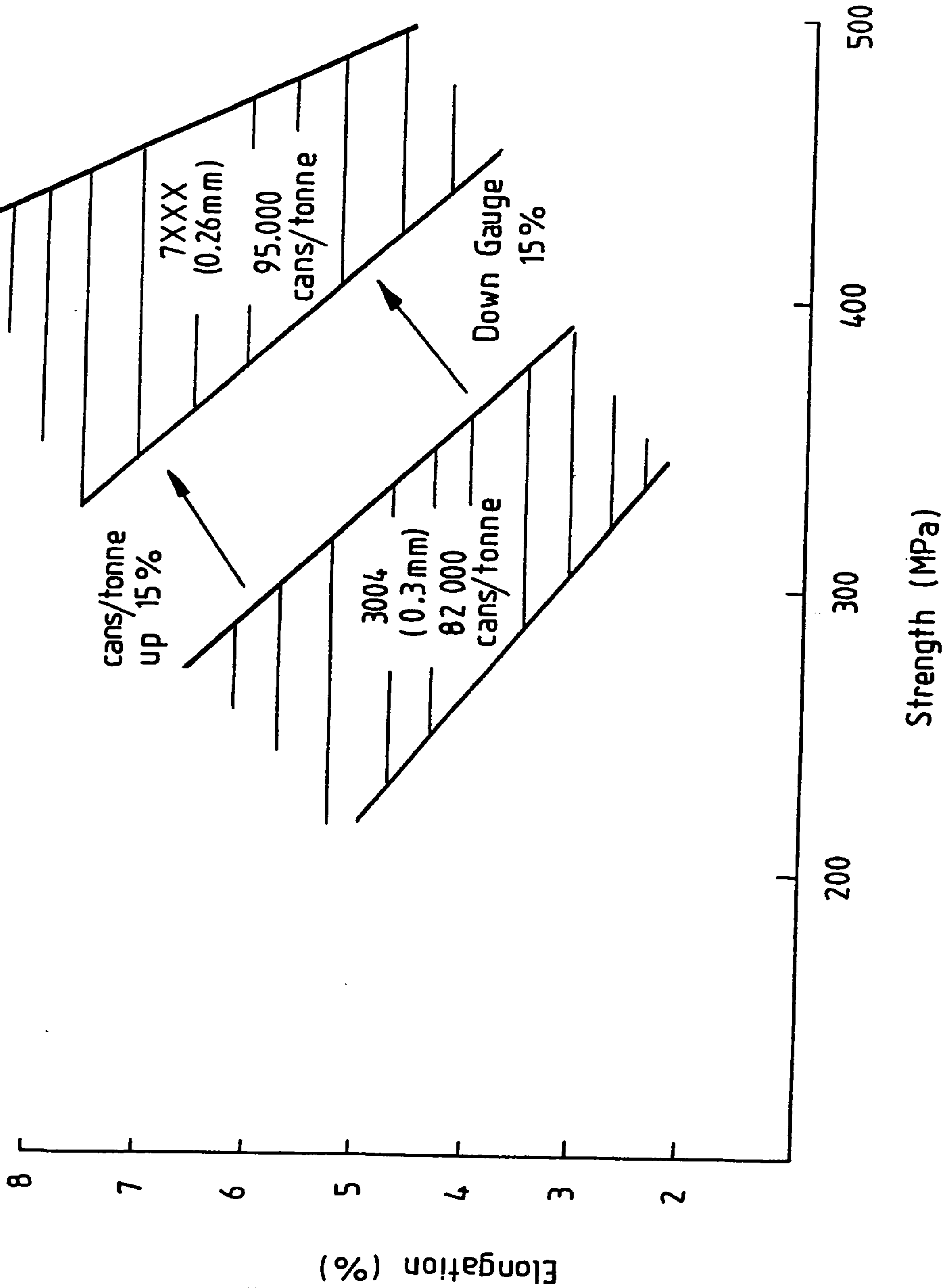

* Yield Strength
Δ Ultimate Tensile Strength
Elongation (%)
Strength (MPa)
3004
A
B
0
1
2
3
4
5
6
7
8
9
10
0
100
200
300
400
500

FIG. 12.

FIG. 13.


7XXX
(0.26mm)
95,000
cans/tonne
Down Gauge
15%
cans/tonne
up 15%
3004
(0.3mm)
82 000
cans/tonne
Elongation (%)
Strength (MPa)
8
7
6
5
4
3
2
200
300
400
500

International Application No . PCT/AU 91/00376

INTERNATIONAL SEARCH REPORT

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent classification (IPC) or to both National Classification and IPC
Int. Cl.[5] C22F 1/053, 1/047; C22C 21/10, 21/08 // B65D 1/12

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	C22F 1/053, 1/047; C22C 21/10, 21/08

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

AU : IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category*	Citation of Document, [11] with indication, where appropriate of the relevant passages [12]	Relevant to Claim No [13]
X	GB,A, 1171144 (VEREINIGTE ALUMINIUM-WERKE AKTIENGESELLSCHAFT) 19 November 1969 (19.11.69) See claim 1.	(13-22)
Y		(1-25)
X	GB,A, 1217765 (CEGEDUR GP) 31 December 1970 (31.12.70) See claims 1 and 2.	(13-22)
Y		(1-25)
X	GB,A, 1186161 (HIGH DUTY ALLOYS LIMITED) 2 April 1970 (02.04.70) See table 1.	(13-22)
Y		(1-25)
	(continued)	

* Special categories of cited documents : [10]

"A" Document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior t the international filing date but later than the priority date claimed

"T" Later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
11 November 1991 (11.11.91)	27 November 91
International Searching Authority	**Signature of Authorized Officer**
AUSTRALIAN PATENT OFFICE	ROGER HOWE

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Y	Aluminium Development Council of Australia, "Aluminium Technology; Book 1; Aluminium The Metal. "Published March 1973 by Ronald Sinclair Associates (Sydney) See page 23 line 10, pages 42-44 and 62-63.	(1-25)
Y	GB,A, 1055687 (SWISS ALUMINIUM LTD) 18 January 1967 (18.01.67) See claims.	(1-12)
A	US,A, 3187428 (REYNOLDS METALS COMPANY) 8 June 1965 (08.06.65) See claims.	(1-12)

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claim numbers , because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers , because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4a

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL APPLICATION NO. PCT/AU 91/00376

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member		
GB 1171144	BE 690170 DE 1483324	CH 476848 LU 52457	CH 488807 NL 6616652
GB 1217765	BE 715298 IL 30014	CH 486601 NL 6806986	ES 353976
GB 1186161	BE 696769	CH 498201	NL 6705011

END OF ANNEX